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Progress Report: Lake Chautauqua Bioresponse Study, 2000

Submitted to the Rock Island District,
U.S. Army Corps of Engineers

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Center for Aquatic Ecology Technical Report 01/09

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Table of Contents

Executive Summary

Adult fish.- Staff from the Illinois Biological Station collected post-construction fish monitoring data from the north pool of Lake Chautauqua in 2000. The gear effort allocated for this year included 60 collections made from four fixed sites. We documented 32 fish species and 2 hybrids along with four turtle species in our catches. A total of 28,328 fish and 22 turtles were collected with gizzard shad being the most numerically abundant (18,837) for fish and red-eared slider (12) for turtles. Day electrofishing collected 58% of the total catch followed by fyke netting 22%, minnow fyke netting 17%, and gill netting 3%. Gizzard shad had the highest CPUE for day electrofishing (820), minnow fyke netting (210.1), and gill netting (49). Freshwater drum had the highest CPUE for fyke netting (117.6).

Due to a flood of high magnitude and duration, fish had almost year-round access to the lake from the Illinois River in 1993. This may have contributed to the highest species richness consisting of 43 species and 2 hybrids. Notable catches in 2000 were a redear sunfish collected in a fyke net, and a single day electrofishing run netted 6,281 young-of-year gizzard shad. There were no fathead minnow captured in 2000, yet there are many other forage species in the lake. (Fathead minnow was found in 1999 during informal surveys requested by the refuge manager.)

The IDNR stocked five managed species in 1999. In the spring the stockings included 400 lbs of bluegill, 100 lbs of black crappie, 200 lbs of fathead minnows, 120,000 fingerling and 40 breeder largemouth bass. Unknown amounts of channel catfish were stocked in the fall. There appears to be natural reproduction in the north pool for all of these species except fathead minnows, according to length histograms. Fisheries in the lake as of 2000 are developing. The largemouth bass length distribution indicates the north pool is showing signs of an improving fishery with many fish available above the 380-mm (15-inch) minimum length limit. Comparisons of length weight relationships for black crappie, largemouth bass, and bluegill, show similar growth patterns to fish found in surrounding areas.

Non-managed species such as gizzard shad, freshwater drum, common carp, white bass, and white crappie appear to have naturally reproducing populations as well. The common carp maybe a species of concern as it may directly compete with the managed fish species as well as having the potential to inhibit the production of submersed aquatic vegetation and increase turbidities.

Larval fish.- At least 21 YOY fish species from 8 families were identified during escapement sampling. High abundances of bighead and grass carp in 2000 escapement samples compared to previous years reinforce previous reports that Lake Chautauqua may serve as spawning habitat for these recently established exotic species. Diet compositions were analyzed for larval and juvenile fish taxa collected during escapement. The diet compositions of larval white bass (<20 mm) and freshwater drum (<10 mm) were comprised almost exclusively of cyclopoid copepods and microcrustacean eggs. Clupeid larvae (4-24 mm) fed on a wider variety of small-bodied invertebrates including rotifers, microcrustacean eggs, cyclopoid and naupliar copepods, cladocerans, and ostracods. Results from this study suggest that the dominance of rotifers and copepod nauplii in Lake Chautauqua make it an ideal habitat for YOY gizzard shad, but not necessarily for centrarchids and white bass YOY. Juvenile white bass (61-142 mm) and largemouth bass (56-89 mm) exhibited very similar diets comprised of *Daphnia lumholtzi*, microcrustacean eggs, corixids, and fish. Our data indicates that smaller size classes of white bass (61-100 mm) and largemouth bass (56-65 mm) juveniles fed primarily on zooplankton and macroinvertebrates, and shifted to a more piscivorous diet after reaching 100 and 72 mm in total length, respectively. *Daphnia lumholtzi* were consumed by several juvenile (white bass, largemouth bass) and adult (emerald shiner) fish, and comprised a significant proportion (47%) of juvenile bluegill (41-63 mm) diets. The results from this study suggest that *D. lumholtzi* may be an important prey item for fish in Lake Chautauqua during the late summer, when abundances of native *Daphnia* species are low, and may fill the gap for larger prey items required by juvenile centrarchids. Because juvenile centrarchids and white bass have shifted their diets from plankton to macroinvertebrates and fish by mid- to late-summer, their survival is likely high in the river system when dewatering occurs later in the summer.

Acknowledgements

Funding for this project was provided by the Rock Island District, U.S. Army Corps of Engineers through the Environmental Management Technical Center of the Biological Resources Division, U.S. Geological Survey with assistance from the Illinois Department of Natural Resources. The views expressed in this report are those of the authors. We thank all station staff that assisted with field and lab work. Cammy Smith was office manager during this project. The cooperation of staff at the U.S. Fish and Wildlife Service's Illinois River Refuges was appreciated. Charlene Carmack, U.S. Army Corps of Engineers, was the project manager for this study.

Chapter 1: Submersed aquatic vegetation in the North Cell of Lake Chautauqua, 2000

Thad R. Cook

Introduction

Monitoring of submersed aquatic vegetation (SAV) in the north pool of Lake Chautauqua was implemented following completion of the Chautauqua Lake HREP construction to estimate the current abundance and to characterize the spatial distribution of SAV.

Methods

We collected SAV data at 42 sites (Figure 1) following methods outlined in the USGS-BRD's Long Term Resource Monitoring Program (LTRMP) (Yin et al. 2000). These methods describe collecting randomized point data over a large area. Points were located by using a differentiated Global Positioning System (GPS) with each point represents a 2-m-wide area around the perimeter of the sampling boat (17 ft) approximately 5 m long and 2 m wide. The area of the sample point is approximately 44 m^2. This technique utilizes a combination of visual examination, rake samples, and a subsampling to quantify the abundance of aquatic species. The rake is a long-handled, double-headed rake (modified from Jessen and Lound [1962] and Deppe and Lathrop [1992]). The rake is made by welding two square-headed garden rakes together, back-to-back, with the teeth of the rakes facing away from one another. The rake is marked into 5 equal parts (or 20% increments). The handle is approximately 3 m long and is scaled in 10-cm increments for measuring water depth. First, a visual assessment is done by recording all species of submersed, rooted floating-leafed, and emergent plants within the area to be raked. The six sub samples of dragging the rake (1.5 m long and 0.36 m wide) along the bottom of the lake are taken at each site. Species-specific presence /absence of aquatic plants are recorded for each site and sub sample combination. Species identification follows Fassett (1957). A total percent rating and a single species density rating are given dependent upon the amount of SAV on the rake. Water depth, substrate sediment type, and the presence of detritus are also recorded. Sediment brought up from the bottom with the rake is examined by sight and touch, and classified into a type. The location of the site is recorded using a Universal Transverse Mercator (UTM) coordinate displayed by the GPS. Data collected using these methods can be used to quantify the abundance of individual species and species groups at each site as well as over a large area where many sites have been surveyed at random.

In addition to the SRS, informal surveys of the lake were made throughout the growing season. The informal means of sampling consisted of boating to areas with suitable habitat most likely to support SAV not covered by SRS. Sites were visually as well as mechanically searched for evidence of plant habitation using the rake sampling technique. An estimate of abundance (rare, common, abundant) would be given to each species dependant on the number of times the species was collected during three rake grabs. Species composition, approximate bed size, water depth, and substrate type were recorded. Geographic locations of any vegetated areas were documented using a GPS to record UTM coordinates.

Transect sampling of the north pool consisted of 2 transects, one parallel with the east shoreline extending the length of the lake, and one perpendicular to the shore extending to the west bank Sampling sites along transects were at estimated intervals of 100 m. Three rake grabs were taken at each site to check for presence or absence of SAV. An estimate of abundance (rare, common, abundant) was given to each species dependant on the number of times the species was collected during the three rake grabs. Depth and substrate type were also recorded.

Results

Following completion of the lake Chautauqua HREP construction in December 1998, water levels within the north pool averaged 1.8 m in 1999. Water levels were lowered prior to the 2000 growing season with an average water depth of 1.2 m. Conditions within the north pool during the 2000 growing season appeared to be favorable for the growth and establishment of SAV. Stratified random sampling (SRS), transect and informal surveying methods for SAV began in May 2000. Submersed aquatic vegetation was found in very low abundance in the north pool and Meyers Ditch through our SRS. Of the 42 random sites, 37 of which were located in the north pool, only one housed a single species of aquatic plant. One individual lotus plant (*Nelumbo lutia*), a rooted floating leaf species, was collected. Average depth of all sites visited was 1.25 m. The predominant substrate in the north pool SRS was silt/clay, with several offshore sites having silt/sand substrates.

Informal surveys of the north pool revealed similar findings to those in the SRS. No submergent vegetation was found throughout the areas visited. However, lotus was found in low numbers (< 30 plants) and usually as individual plants at offshore locations, predominantly in the northeast corner of the lake. Substrate type where lotus was found was dominated by silt/clay. Further more, we found no SAV at shoreline sites where we predicted their presence. Shoreline habitats appeared to be suitable (water transparencies, depth, and substrate) (see fish section WQ) for growth and establishment of SAV, but only sizable clumps of filamentous algae were found growing in these areas. Substrate types ranged from silt/clay to pure sand. Water depths of shoreline habitats visited ranged from 0 to 1.0 m.

Transect sampling results were similar to those of the SRS and informal surveys. No floating leaved vegetation was found along either transect. However, one submergent species, slender pondweed (*Zannichellia palustris*) was found along the perpendicular transect. Only one specimen was found along either transect. Water depth at this site was 1.1 m with a substrate of silt/clay /sand.

Discussion

The presence of two species of aquatic plants within the lake two years following completion of the HREP suggests return of SAV is still possible. However, our findings within Lake Chautauqua were not unlike those in contiguous backwaters in the same region of the Illinois River (ie. Rice Lake and Big Lake RM 135.0) in 2000. Stable water levels with depths of approximately 1.0 m and a silt/clay/sand substrate were found at Rice and Big Lake. Although water transparencies were lower within these semi-connected lakes, lotus was present in sparse numbers in areas it had not been found in recent years.

Fish assemblages within Lake Chautauqua may help to explain the inability of SAV to establish in sizable numbers, although it is just one of many factors involved.

For example, fish collections taken within Lake Chautauqua are similar to those taken from other backwaters such as Big Lake and Anderson Lake (RM 111.0). These backwater lakes have similar numbers and species of fish to those found in Lake Chautauqua, and have very little or no SAV. Anderson Lake was found to have small patches of sago pondweed (*Potamogeton pectinatus*) in 2000 along shoreline habitats similar to those found in Lake Chautauqua. Again, this species was not found in sizable numbers at Anderson Lake, but the presence of this and other species within a backwater lake of the Illinois River suggests sizable stands of SAV may be possible given the proper conditions.

Conclusion

Many possible limiting factors threaten the establishment and growth of SAV within Lake Chautauqua and other isolated and contiguous backwaters of the Illinois River. Some of these include invasive fish, such as grass carp (*Ctenopharyngodon idella*), seed supply limitations, water quality, herbicides as well as others. With the large number of human-induced alterations to the river system, there are still many unanswered questions regarding the loss and re-establishment of SAV within backwater lakes. Continued evaluation of this and other HREP projects, coupled with focused research of factors limiting SAV will help measure success of habitat improvement and direct future goals and objectives of rehabilitation projects. Given the complexity of this and other backwater lakes, resource managers will continue to be challenged to manage the various aquatic habitats in this dynamic system.

References

Deppe, E., and R.C. Lathrop. 1992. A comparison of two rake sampling techniques for sampling aquatic saprophytes. Wisconsin Department of natural Resources. Findings 32. PUBL-RS 732-92. 4 p.

Fassett, N.C. 1957. A manual of aquatic plants. University of Wisconsin Press, Madison. 405 pp.

Yin, Y., J.S. Winkleman, and H.A. Langrehr. 2000. Long Term resource Monitoring Program procedures: Aquatic vegetation monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. April 2000. LTRMP 95-P002-7. 8 pp. = Appendixes A-C.

Chapter 2: Adult fish population dynamics in the North Cell of Lake Chautauqua

T. M. O'Hara, K. S. Irons, and M. A. McClelland.

Introduction

Lake Chautauqua, an isolated Illinois River backwater, is a wet soil management unit operated primarily as a refuge for migrating waterfowl by the U.S. Fish and Wildlife Service. This lake is part of the Illinois River Refuges and construction of the cross and perimeter levees, pumps, and control sturcture at Lake Chautauqua was implemented as part of the Environmental Management Program (EMP). A main feature of this project was dividing the lake by a cross levee into two management areas: a north pool and a south pool. The management plan for the north pool of Lake Chautauqua includes management for stable water levels with the intended outcome of a high quality fishery coupled with environmental conditions that will promote submersed aquatic vegetation. The south pool is drained and managed for moist soil conditions that produce habitat and food plants that are flooded in the fall for migrating waterfowl and shorebirds. However, the south pool is also highly successful in producing fish in the spring of the year as demonstrated by fish production and escapement studies (summarized in this report).

This chapter summarizes fish data collected during 2000 for bioresponse monitoring at the Lake Chautauqua Habitat Rehabilitation and Enhancement Project (HREP). This effort represents the first year of post-construction data collected. This data will be used, in part, to evaluate the success and development of the HREP project using limited historical information for comparisons. Data were collected by staff at the Illinois Natural History Survey's (INHS) Illinois River Biological Station, at Havana, Illinois. This field station is one of six field stations that are participating in the Long Term Resource Monitoring Program (LTRMP). The LTRMP has set standards for routine monitoring of six reaches on the Upper Mississippi River System, which includes the Illinois River. This standardized data collection allows comparisons to be made spatially and temporally. Using these standard methods for project evaluation increases opportunities to detect trends and make comparisons as the same methods are used in and out of the project area.

Methods

Following LTRMP protocols, we sampled four sites in the north pool at Lake Chautauqua (Figure 1) using day electrofishing, fyke netting, minnow fyke netting, and gill netting. Water levels within the lake were stable (436 ft MSL), allowing successful completion of all effort in 2000. Because of periodic connection to the river prior to construction (1991-93), sampling was not as complete, and some had been suspended due to low water levels. A third of the effort was completed in each of 3 time periods [spring (Jun 15-Jul 31), summer (Aug 1 – Sep 15), fall (Sep 16 – Oct 31)] throughout the 2000 sampling season. We used gill nets in open water to supplement our sampling efforts beyond LTRMP protocols (Appendix I. Gear and Methods Summary). Historical data at Lake Chautauqua had been collected in the same fashion (Burkhardt et. al 1988, Gutreuter et. al 1995, Harvey 1992, Blodgett-Irons 1993, Blodgett et. al 1994).

The four sites we sampled at Lake Chautauqua in 2000 were in two habitats (or strata). Three sites (7, 9, and 11) were located along shoreline (BWI-S) habitat, and one site (8) located offshore (BWI-O) habitat. These were the same locations sampled previously, and have been documented using Geographic Information System (GIS). Sites were found and remarked in 2000 by using Global Positioning System (GPS) receivers to maintain accuracy through time (Figure 1., Appendix II. Site Descriptions). The shoreline sites were sampled in each of the 3 time periods with: 2 electrofishing runs, 2 fyke nets, and 2 minnow-fyke nets. The offshore site was sampled only with 2 experimental gill nets in each of the time periods (Table 1). All electrofishing runs were 15 minutes in duration, and all nets were set for 1-24 hour day. Non-standardized sampling occurred in 1999 at the request of the refuge manager. Six-15 minute runs were completed at various locations in May 1999. The results and observations are included in Appendix III. This data was presented to refuge manager in May 1999.

Fish were identified to species in the field and measured for total length. Additionally, a subsample of each species was weighed during third time period. All information was recorded on LTRMP data sheets and entered through a contracted data entry firm. We verified accurate data entry at the field station. Data used for historical comparisons were taken from previous reports.

We also measured several water quality parameters following LTMRP protocols. We measured conductivity (μS/cm), dissolved oxygen (DO; mg/l), secchi disk (cm), turbidity (nephlometric turbidity units [ntu]), and water temperature (°C) at each site. Average, minimum, and maximum values of all variables collected during 2000 will be summarized. In addition, Daily & Associates were contracted to collect water quality information on Lake Chautauqua for the U.S. Army Corps of Engineers.

Results of 2000 sampling will be summarized in several ways. First, effort and catch summaries will be presented and compared to historical (1991-1993) data. Second, population information about several species targeted specifically for management at Lake Chautauqua will be presented. These species will be referred to as "managed species": 1) Largemouth bass *Micropterus salmoides*, 2) Bluegill *Lepomis macrochirus*, 3) Black crappie *Pomoxis nigromaculatus*, 4) Channel *catfish Ictalurus punctatus*, and 5) Fathead minnow *Pimephales promelas*. In addition, population stock density (PSD) and relative stock density (RSD) will be presented for these managed species (Gablehouse 1984). Third, population information "non-managed species" such as 1) Gizzard shad *Dorosoma cepedianum*, 2) Common carp *Cyprinus carpio*, 3) White bass *Morone chrysops*, 4) Freshwater drum *Aplodinotus grunniens*, and 5) White crappie *Pomoxis annularis* will be presented. Fourth, a brief summary of turtles collected during our samplilng will be presented. And fifth, a brief summary of water quality parameters from the north pool will be included.

Catch-per-unit-effort (CPUE) for electrofishing will be expressed as number of fish caught per run, and CPUE for netting will be expressed as number of fish caught per net day.

Table 1. Fish sampling gears and efforts for Lake Chautauqua HREP Bioresponse monitoring from 1991-2000.

	Day Electrofishing BWI-S				Fyke Net Sets BWI-S				Minnow-Fyke Net Sets BWI-S				Gill Net Sets BWI-O				Seine Hauls BWI-S			
Site #	1991	1992	1993	2000	1991	1992	1993	2000	1991	1992	1993	2000	1991	1992	1993	2000	1991	1992	1993	2000
(07)	0	2	4	6	2	4	4	6			4	6					2	4		
(11)			2	6	4	4	2	6		2	2	6			3					
(09)		2	4	6	5	4	15	6			5	6						4		
(08)													1	4	4	6				

Effort and Catch summaries

2000 Effort

The total effort scheduled for 2000 was similar to efforts scheduled in previous years (1991-1993). A total of 60 collections were made at the four fish sites in 2000. From 15 June through 31 October 2000 we
completed a total of 4.5 hours of day electrofishing, 18 fyke net sets, 18 minnow-fyke net sets and 6 gill net sets. Seining was not used in 2000 (Table 1).

2000 Catch Summary

Day electrofishing collected 16,329 fish consisting of 58% of the total catch and 25 species and 2 hybrids. Gizzard shad had the highest CPUE of 820, followed by bluegill (31.6) and largemouth bass (17) (Table 2). On 17 July 2000, we netted 6,281 young of year gizzard shad during a single electrofishing run at site (07).

Fyke netting collected 6,294 fish consisting of 22% of the total catch and 24 species and one hybrid. The CPUE was highest for freshwater drum (177.6), followed by bluegill (68.9) and black crappie (60.1) (Table 2). A fyke net deployed 25 September 2000 at site (07) produced 2,904 freshwater drum that accounted for 46% of the total fyke net catch.

Minnow fyke netting collected 4,884 fish consisting of 17% of the total catch and 16 species. The CPUE was highest for gizzard shad (210.1), followed by bluegill (40.5) and bullhead minnow (9.5, Table 2). A minnow fyke deployed 6 July 2000 at site (09) netted 1,211 young of year gizzard shad that accounted for 24 % of the total minnow fyke catch.

Gill netting collected 822 fish consisting of 3% of the total catch and 17 species. The CPUE was highest for gizzard shad (49.0), followed by freshwater drum (41.8) and white bass (17.3) (Table 2.). All gizzard shad caught by gill netting were adult fish 200 to 440 mm in size.

Annual Catch–(1991-1993, 2000)

Since 1991, 40,604 fish comprising of 44 species and 2 hybrids have been documented in the north pool of Lake Chautauqua. A total of 28,328 fish consisting of 32 species and 2 hybrids were collected in 2000 (Table 3.). Species richness in 2000 was not the highest documened at Lake Chautauqua, although this was the highest number of total fish collected out of the four years sampled. In 1993, a total of 3,549 fish were collected consisting of 43 species and 2 hybrids.

The five most numerically abundant species in 2000, were gizzard shad (18,837), freshwater drum (3,519), bluegill (2,552), black crappie (1,205) and white crappie (739). One unique species, redear sunfish *Lepomis microlophus,* was captured in 2000. This occurrence is probably a result of stockings during the previous year. The 1993 fish sampling produced the most unique species (12) most likely the result of prolonged connection to the river.

Freshwater drum were the most dominant fish collected in 1991 followed by gizzard shad and bluegill. In all other years gizzard shad has been most dominant (1992-1993, 2000). Freshwater drum and bluegill were second and third in abundance in 1992 and 2000, with common carp being second in 1993, followed again by bluegill (Figure 2).

Managed Species Summary

The Illinois Department of Natural Resources (IDNR) stocked 182 kg of bluegill, 113.4 kg of black crappie, 91 kg of fathead minnows, and 120,000 largemouth bass (25-50 mm) in the spring of 1999. Further stockings of 40 adult largemouth bass and 20,000 channel catfish (~150 mm) continued in the summer and fall of 1999. Because of concerns over genetic stocks, bluegill and bass stocks originated at Spring Lake, Tazwell County, Illinois (adjacent to project area) and raised at Jake Wolf Fish Hatchery, Manito, IL. Channel catfish came from IDNR-Little Grassy Fish Hatchery and were of unspecified stocks (Dan Stephenson, personal communication).

A total of 2,552 bluegill were captured with all gears in 2000. The length distribution (Figure 3) shows fish ranging 10 to 200 mm (PSD = 4.00; RSD[200] = 0.35). Two peaks were present in this distribution; one at 30 mm representing natural reproduction in 2000 and one at 120 mm representing fish produced in the lake or stocked the previous year. Length-weight relations of bluegill from Lake Chautauqua were compared to bluegill from Anderson Lake and LTRM fish data from La Grange Reach (Figure 4). Evidence suggests that bluegills from Lake Chautauqua exhibit similar trends compared to bluegill from other areas in the same geographic region.

A total of 1,205 black crappie were captured with all gears in 2000. The length distribution (Figure 5) shows fish ranging from 20 to 330 mm (PSD = 48.22; RSD[250] = 1.16). There were no black crappie caught from 80-120 mm, and from 270-280 mm. Two major peaks were present in this distribution one at 40 mm representing natural reproduction in 2000 and at 200 mm that may represent fish produced in the lake or stocked in the previous year. Length and weight relationships of black crappie from Lake Chautauqua were compared to black crappie from Anderson Lake and LTRM fish data from La Grange Reach (Figure 6). It appears black crappies from Lake Chautauqua are expressing similar growth trends as black crappie from these other areas.

A total of 336 largemouth bass were captured with all gears in 2000. The length distribution (Figure 7) shows fish ranging from 30 to 430 mm(PSD = 27.21; RSD[380] = 2.72). There is no clear indication of year class peaks. Length and weight relations of largemouth bass from Lake Chautauqua compared to largemouth bass from Anderson Lake and LTRM fish data from La Grange Reach (Figure 8) indicate similar growth trends across all areas.

A total of 44 channel catfish were captured in 2000. The length distribution (Figure 9) shows fish ranging from 80 to 610 mm (PSD = 69.23; RSD[200] = 0.35). The small sample size in this distribution does not provide clear size class peaks. However, there is limited evidence of natural recruitment with the presence of young-of-the year channel catfish.

Fathead minnows were not captured in 2000. This fish was stocked in 1999 to provide forage for Centrarchid species in the lake. However, gizzard shad, golden shiners, bullhead minnows, and emerald shiners were collected providing excellent forage for several species in the lake.

Non-Managed Species Summary

A total of 18,837 gizzard shad were captured with all gears in 2000. The length distribution (Figure 10) shows fish ranging from 30 to 440 mm, however 95% of the gizzard shad catch was less than 70 mm indicating strong natural reproduction in the lake.

A total of 184 common carp were captured with all gears in 2000. The length distribution (Figure 11) shows fish ranging from 30 to 640 mm. Two peaks were present in this distribution one at 70 mm that represents natural reproduction in 2000 and at 510 mm being the reproducing adult population. There were no common carp caught between the size groups 130 mm and 340 mm.

A total of 739 white crappie were captured with all gears in 2000. The length distribution (Figure 12) shows fish ranging 20 to 330 mm. Two peaks were present in this distribution one at 40 mm representing natural reproduction in 2000 and at 230 mm representing fish produced in the lake.

A total of 3,519 freshwater drum were captured with all gears in 2000. The length distribution histogram (Figure 13) shows fish ranging 50 to 450 mm. Two peaks were present in this distribution one at 130 mm representing natural reproduction in 2000 and at 220 mm being fish produced in 1999.

A total of 180 white bass were captured with all gears in 2000. The length distribution (Figure 14) shows fish ranging 50 to 450 mm. Two peaks were present in this distribution one at 130 mm representing natural reproduction in 2000 and 220 mm being fish produced in 1999.

Turtle Catch Summary

During our 2000 fish sampling efforts, 21 turtles consisting of 4 species were captured. Red-eared slider turtle *Trachemys scripta elegans* were the most numerically abundant with 12 being caught, followed by common musk turtle *Sternotherus odoratus* (5), western painted turtle *Chrysemys picta bellii* (3) and eastern spiny softshell turtle *Trionyx spinifer spinifer* (2). Fyke netting captured 20 turtles while day electrofishing and minnow fyke netting captured one each.

Water quality

Conductivity from all sites sampled in 2000 ranged from 351 to 510 µS/cm with an average of 440.9 µS/cm. The DO from all sites sampled ranged from 5.4 to 12.6 mg/l with an average of 9.5 mg/l. Secchi disk readings from all sites ranged from 12 to 50 cm with an average of 24.2 cm. Turbidity from all sites sampled ranged from 15.9 to 225.0 with an average of 65.5 ntu's. Temperature from all sites sampled ranged from 12.4 to 32.3° with an average of 23.9°(Figure 15, Daily & Associates 2000). Depth from all the shoreline sites averaged 0.8 m and offshore sites averaged 1.2 m.

References

Blodgett, K.D., K.S. Irons, T.R. Cook. 1994. Progress Report: Bioresponse Monitoring at Peoria Lake and Lake Chautauqua Habitat Rehabilitation and Enhancement Projects. Submitted to U.S. Army Corps of Engineers, Rock Island District, Rock Island, IL.

Burkhardt, R. W., K. S. Lubinski, and J. L. Rasmussen. 1988. Fish. Pages 7.1-7.55 in Procedures manual of the Long Term Resource Monitoring Program for the Upper Mississippi River System. U. S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin.

Daily & Associates. 2000. Unpublished data, Water quality monitoring results from samples collected at W-I129.4T, Lake Chautauqua, 2000.

Gablehouse, D. W., Jr. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Gutreuter, S., R. Burkhardt, and K. Lubinski. 1995. Long Tern Resource Monitoring Program Procedures: Fish Monitoring. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, July 1995. LTRMP 95-P002-1. 42 pp. + Appendixes A-J

Harvey, James R. 1992. Midterm report on pre-construction sampling at Chautauqua and Peoria Lake HREP areas. 48 p.

Irons, K. S., K. D. Blodgett. 1993. Annual Progress Report for Bioresponse Monitoring of Habitat Rehabilitation and Enhancement Projects (HREP's) for Peoria Lake and Lake Chautauqua. 45p.

Stephenson, Dan, personal communication, Illinois Department of Natural Resources, Fisheries, District 14 Fisheries Manager, P.O. Box 298, Petersburg, IL 62675. (217) 632-3841

Appendix I: Gear and Methods Summary

Electrofishing

We used a 5.5-meter (m) welded aluminum plate boat powered by a 115-hp outboard. A 5-kW generator supplied 250-volt alternating current (AC) to a control box (built by Burke O'Neal, University of Wisconsin - Madison, Engineering Technical Services) mounted near the pilot. The control box converted AC to pulsed-direct current (DC) with voltage, amperage, and duty cycle and pulse rate controlled by the pilot. Pulsed-DC was delivered by two 1-m diameter stainless steel rings supported by two booms at the bow of the boat. Four equally spaced stainless steel droppers (anodes) were suspended from each ring. The boat hull acted as the cathode. This equipment allowed us to produce pulsed-DC fields of varying wattage with consistent dimensions.

Electrofishing runs were to be 200 m in length and 15 minutes (min) in duration. Distance and time sampled were recorded for each run because some habitat types required more or less than 15 min to sample. Before each electrofishing run we measured water temperature and specific conductance to identify proper voltage and amperage settings needed to reach the power goal for the 4500-watt power base. We also measured secchi disk transparency and maximum water depth.

Two dippers used 2.4-m long dip nets with 25.4 cm deep, 3 mm mesh bags. Dippers netted each fish as it appeared, regardless of size or species.

Fyke netting

We used large, Wisconsin-type fyke nets made of black asphalt-coated No. 12 nylon twine with 1.8-cm-bar mesh. Each net had three sections: a 15 m lead; a cab that was formed by two spring steel frames 1 m tall and 2 m wide; and a hooped section consisting of six, 0.9-m-diameter steel hoops. In backwater habitats, large fyke nets were set perpendicular to the shore with the lead secured at the water's edge. When set in vegetated areas, the lead was secured 1 m into the vegetation bed and extended perpendicular to the vegetation edge.

We also used small Wisconsin-design minnow fyke nets made of green-dipped 3-mm-mesh "Ace" nylon netting consisting of 3 sections similar to those of the fyke nets. However, the dimensions for each section varied significantly. The lead was 6.1 m long and 0.6 m tall; the cab formed by two steel frames, was 0.6 m tall and 1.2 m wide; and the hooped section consisted of two, 0.6-m-diameter steel hoops. Small (minnow) fyke nets were set in a similar fashion as the methods described for fyke nets.

Gill Netting

We used gill nets to sample open-water sites in place of tandem fyke nets starting in 1992, because the use of tandem fyke nets following LTRMP protocols produced low catches in 1991 (Harvey, 1992). The use of gill nets by commercial fishermen has been an effective gear in catching the larger bodied commercially valuable species such as buffalo and catfish. Our experimental gill nets measured 91.4 m (300 ft) long, 1.2 m high, with six panels of various-size meshes arranged in a random fashion. Each panel was 15.2 m (50 ft) long with monofilament mesh of 6.4-, 11.4-, 16.5-, 8.9-, 14.0-, or 3.8-cm (2.5-, 4.5-, 6.5-, 3.5-, 5.5-, or 1.5-inch) stretched mesh. Two gill nets were set parallel to each other at each site, roughly 100 m apart. The bottom set nets were kept open on both ends with 1.2-m wooden bridles, which also aided in setting the nets. A sand anchor, anchored the first end tossed from the boat and the trailing end was anchored by a concrete weight. The nets were set with the bow of the boat into the wind and the motor in reverse. Floats were attached to the ends and the center of the net so it would be visible to boaters. Gill nets were set for 24 hours.

Fish Handling

Upon collection, fish were immediately placed in a holding tank. Fish were then identified to species, weighed to the nearest gram (g); measured to the nearest millimeter total length (mmTL), and examined for external parasites and physical abnormalities. All fish were released immediately after processing, except for those retained for reference collections or to verify identification (Harvey 1992).

Appendix II: Site descriptions

Site 7, a shoreline site, was on the north side of the cross levee; the site was split by an opening in the levee which connected the two pools before construction. This site was just off the sandy shoreline and was deeper than any of the other Chautauqua sites including the open-water site.

Site 8, a open-water site, was 400 m offshore and directly north from the opening in the levee. This site was fished only with gill nets.

Site 9, a shoreline site, was on the upper part of the north pool. It was typical of the lake's east bank with many in-flowing springs. Site 09 also had flooded terrestrial grasses and submerged stumps offshore.

Site 11, a shoreline site, was along the west shore of the lake near the west levee. This site had a gradual slope and was lined with flooded willows throughout the year. Fyke nets at this site were anchored just inside the edge of the willows.

Appendix III: 1999 Informal Sampling of Lake Chautauqua

The results of 3-15 minute shocking runs in North Pool, May 7, 1999.

Three of the quantified runs were along the cross-levee, at sights sampled prior to construction. Each run covered approximately 200-250m of shoreline.

Run 1- bare cross-levee - *3 fish*

2 White bass (5-7 inches)
1 Gizzard shad (7 inches)
(1 Bowfin and 1 largemouth bass seen but could not net)

Run 2- bare cross-levee - *2 fish*

2 Fathead minnows (2-3 inches)

Run 3- Cove by pumphouse on west end of cross-levee (Polygonum and other emergent vegetation present.)- *15 fish*

1 Carp (15 inches)
2 Shortnose gar (20-23 inches)
1 Longnose gar (17 inches)
1 Rivercarpsucker (16 inches)
1 White bass (11 inches)
2 Largemouth bass (8-12 inches)
1 Bowfin (26 inches)
1 Redear sunfish (6 inches)
1 bluegill (6 inches)
3 Gizzard shad (7-10 inches)
1 Fathead minnow (2 inches)
--could not net numerous gar and other fish

We were also able to sample adjacent to the new water control structure briefly, without counting fish, but were able to identify a large number of bigmouth and smallmouth buffalo, large shad > 12 inches, white bass, bullhead (sp.), and at least one largemouth bass > 17 inches and > 3 lbs. We anticipate spending another afternoon on the lake to enumerate some catches at other sites (including a site at the control structure).

Secchi disk at the sites along the cross-levee were 12 cm with water temperatures at 15.4°C (60°F) with dissolved oxygen levels between 5.7 and 6.5. We were not able to get water quality from the south pool on this date.

The results of 3-15 minute shocking runs in North Pool, May 14, 1999.

Three of the quantified runs were along the north section of the lake, at sites sampled prior to construction. One of these runs occurred at the new water control structure.

Each run covered approximately 200-250m of shoreline.

Run 1- Site 9 - bluff side of lake (1 of 2) - *7 fish*

1 White bass (5 inches)
2 Common carp (15 - 17 inches)
1 River carpsucker (10 inches)
1 Bigmouth buffalo (16 inches)
1 Freshwater drum (4 inches)
1 Largemouth bass (7 inches)

Run 2- Site 9 - bluff side of lake (2 of 2) - *11 fish*

3 White bass (7 - 11 inches)
1 Carp x goldfish hybrid (15 inches)
2 River carpsucker (16-17 inches)
1 Bigmouth buffalo (13 inches)
1 Bluegill (3 inches)
2 Largemouth bass (4 inches)
1 Gizzard shad (4 inches)

Run 3- Site PS25 - North Control Structure - *49 fish*

1 Black crappie x White crappie Hybrid (11 inches)
6 Black crappie (9-11 inches)
3 Fathead minnow
1 Sauger (8 inches)
2 White bass (11-14 inches)
2 Red shiner
4 Emerald shiner
1 Smallmouth buffalo (11 inches)
2 Bigmouth buffalo (15-18 inches)
1 Bluegill (3 inches)
1 River carpsucker (17 inches)
15 Shortnose gar (17-23 inches)
2 longnose gar (18-19 inches)
5 Gizzard shad (4-9 inches)
3 Common carp (11-20 inches)

4 Redear slider turtles (3 inches)

Secchi depths at the sites along the north bluff on 14 May were 28-35 cm with water temperatures from 18.9 to 20.2°C (66 to 68°F) with dissolved oxygen levels between 8.2 and 10.2.

<u>Summary of 1999 informal sampling.</u>

Total shocking effort 6 x 15 minutes = **1.5 hours**, 87 fish / 1.5 = **58 fish per hour (Total)**
Largemouth bass 5 /1.5 = 3.33 bass/hour
Gar sp. 20/1.5 = 13.3 gar/hour

Total Species collected = **18 species** (+ 2 hybrids)

Best run 49 fish / .25 = **196 fish per hour** at control structure.

Worst run 2 fish / .25 = **8 fish per hour** at cross-levee.

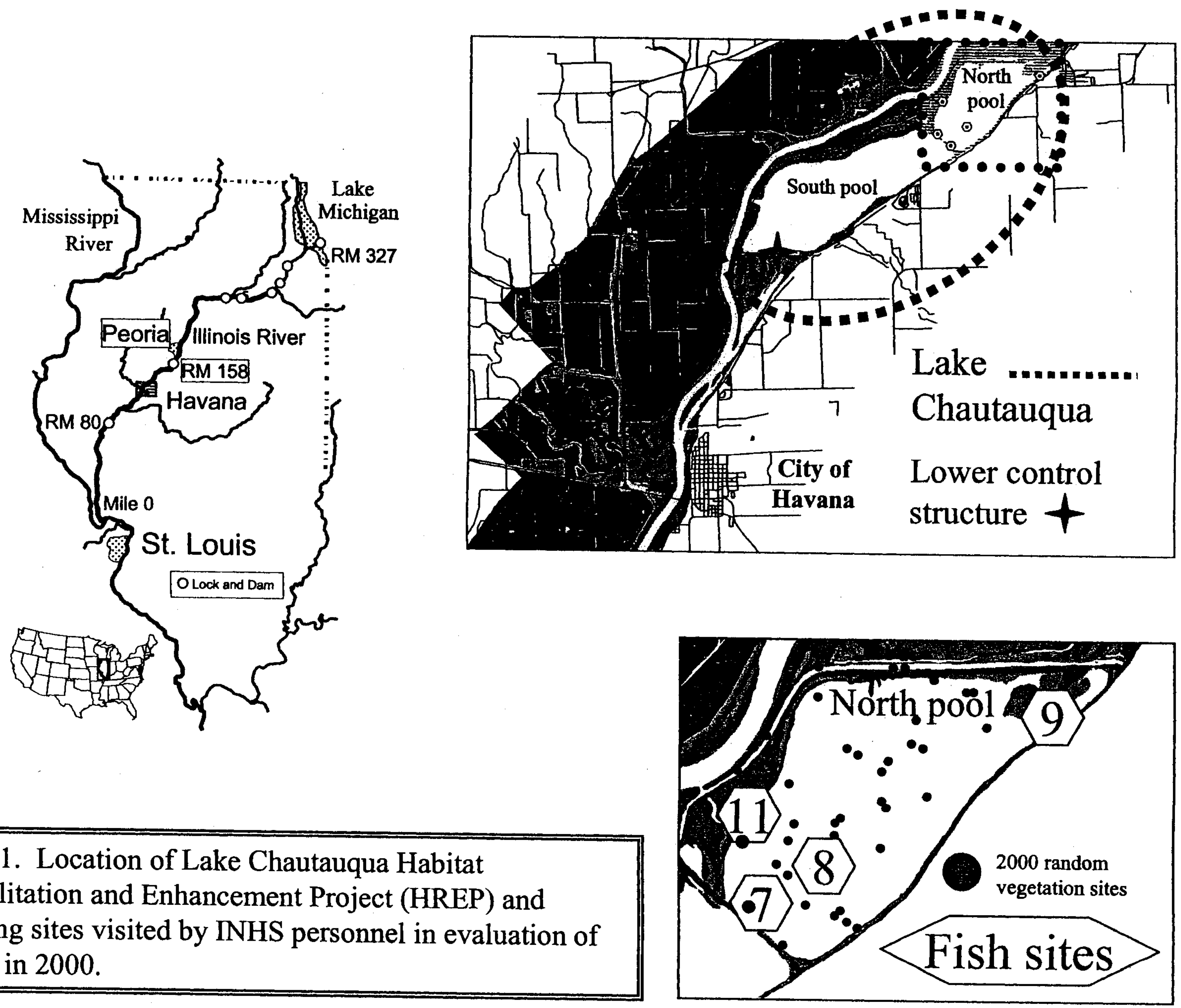


Figure 1. Location of Lake Chautauqua Habitat Rehabilitation and Enhancement Project (HREP) and sampling sites visited by INHS personnel in evaluation of project in 2000.

Figure 2. Percentages of species 1991 – 2000.

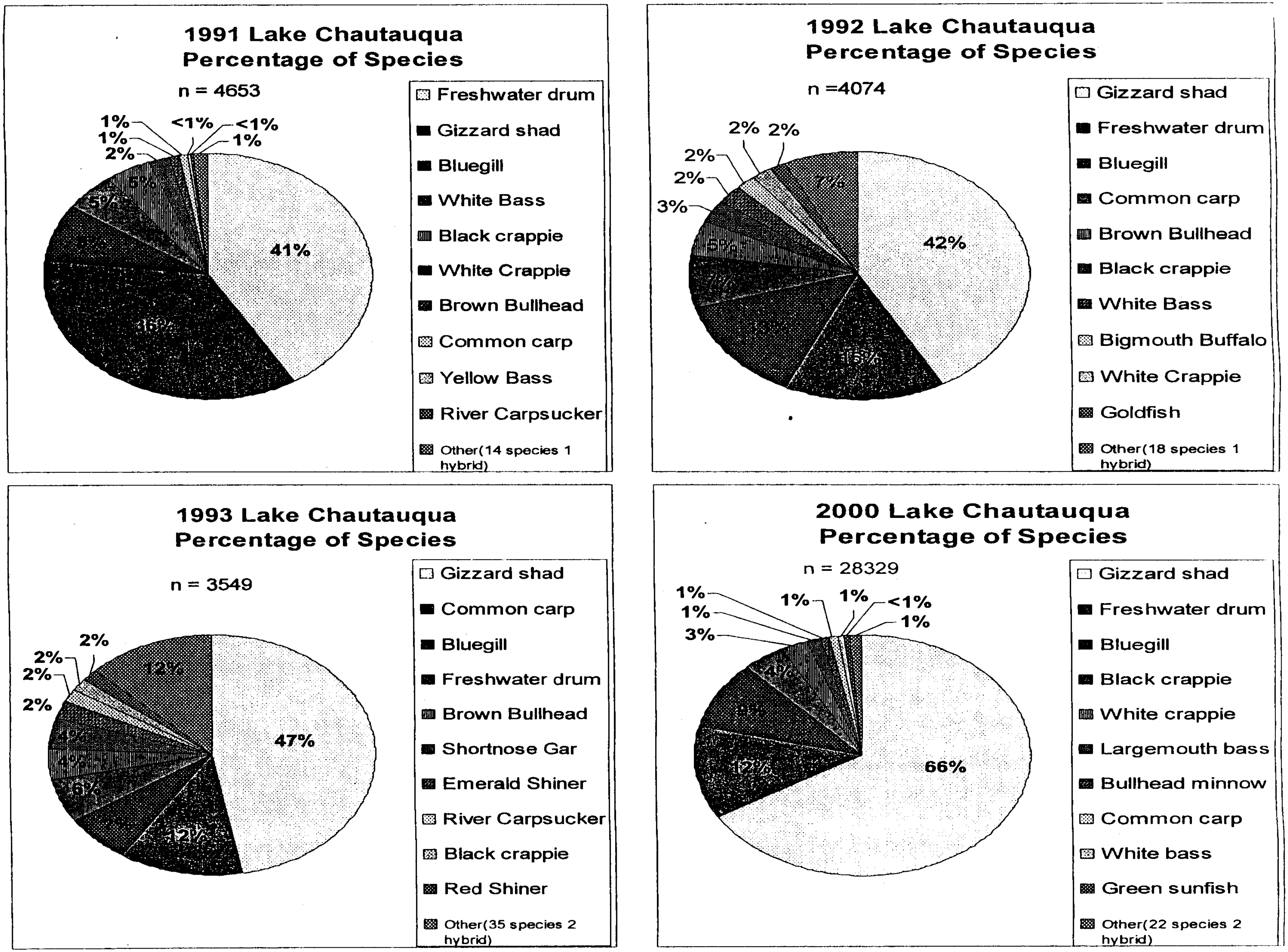
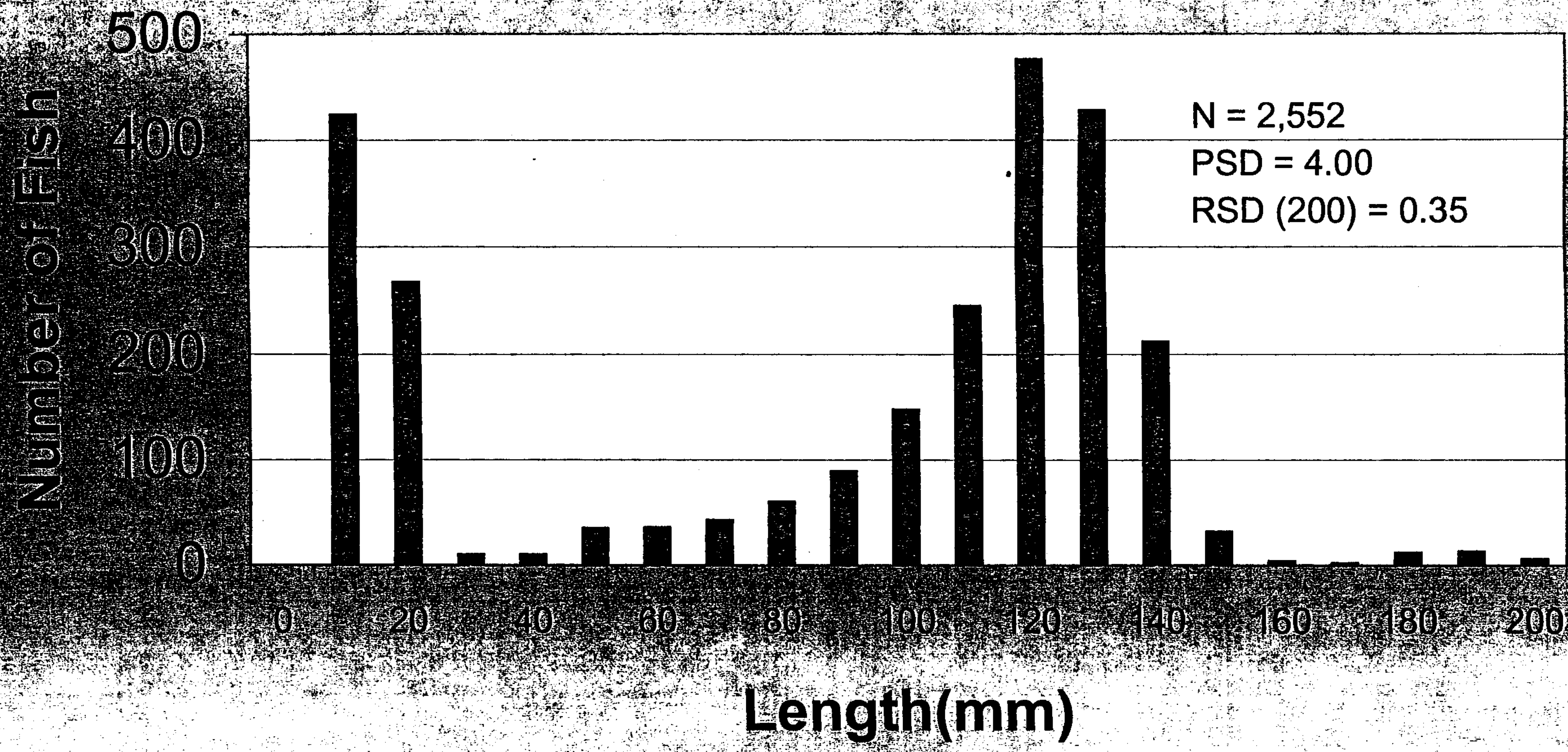


Figure 3. 2000 Lake Chautauqua Bluegill Length Distribution



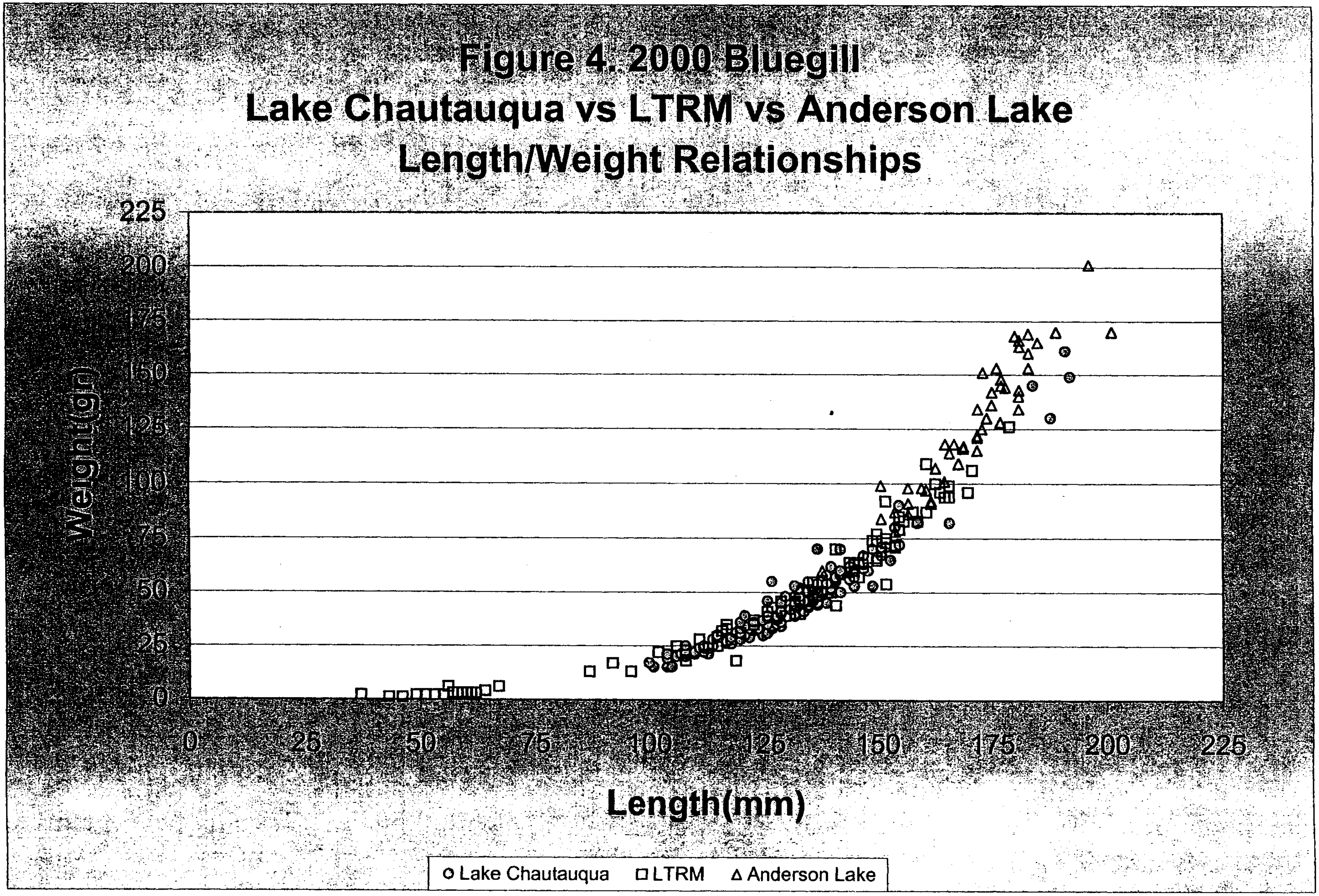
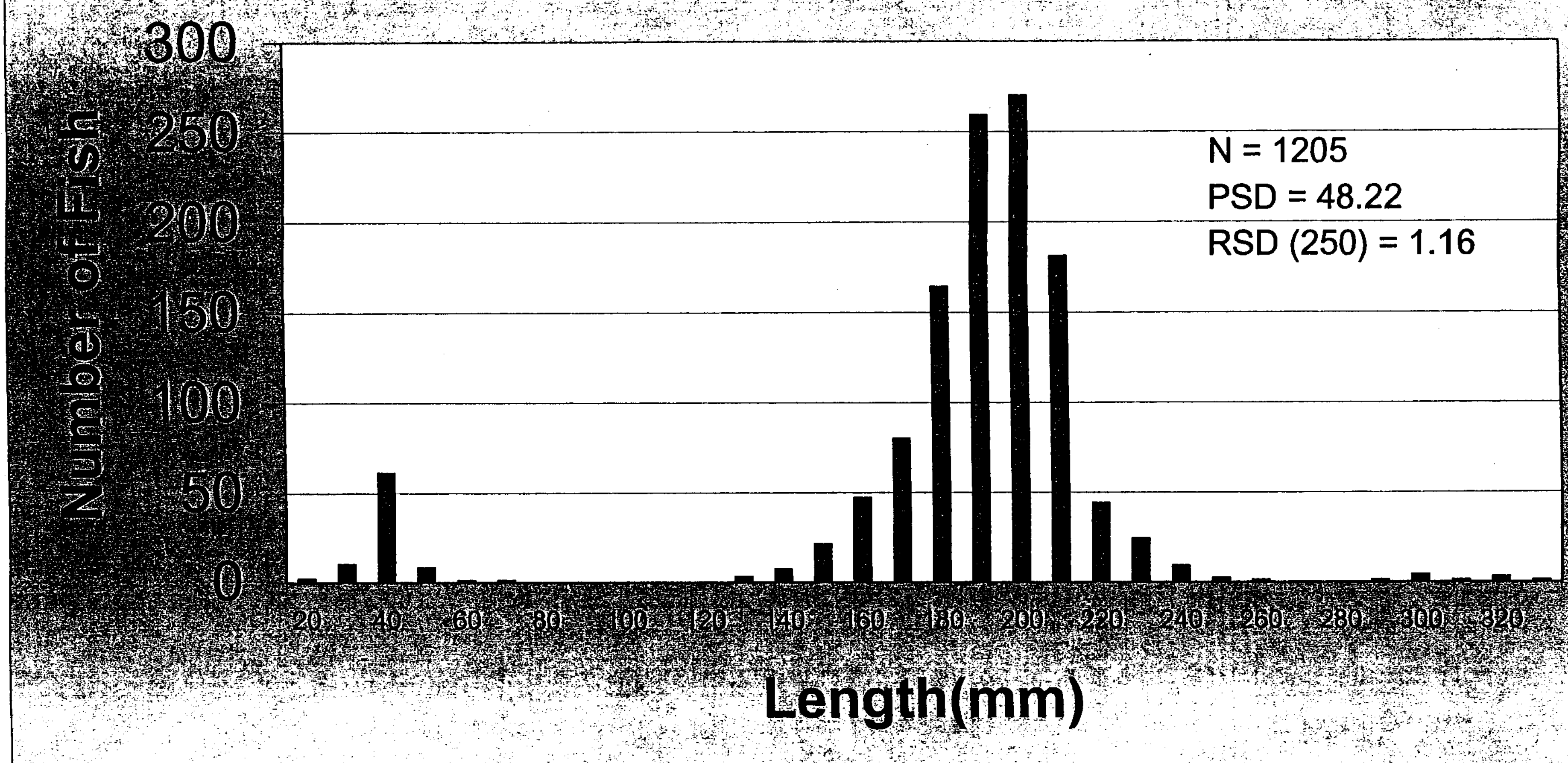


Figure 4. 2000 Bluegill
Lake Chautauqua vs LTRM vs Anderson Lake
Length/Weight Relationships
Weight(gr)
225
200
175
150
125
100
75
50
25
0
0
25
50
75
100
125
150
175
200
225
Length(mm)
Lake Chautauqua
LTRM
Anderson Lake

Figure 5. 2000 Lake Chautauqua
Black Crappie Length Distributions



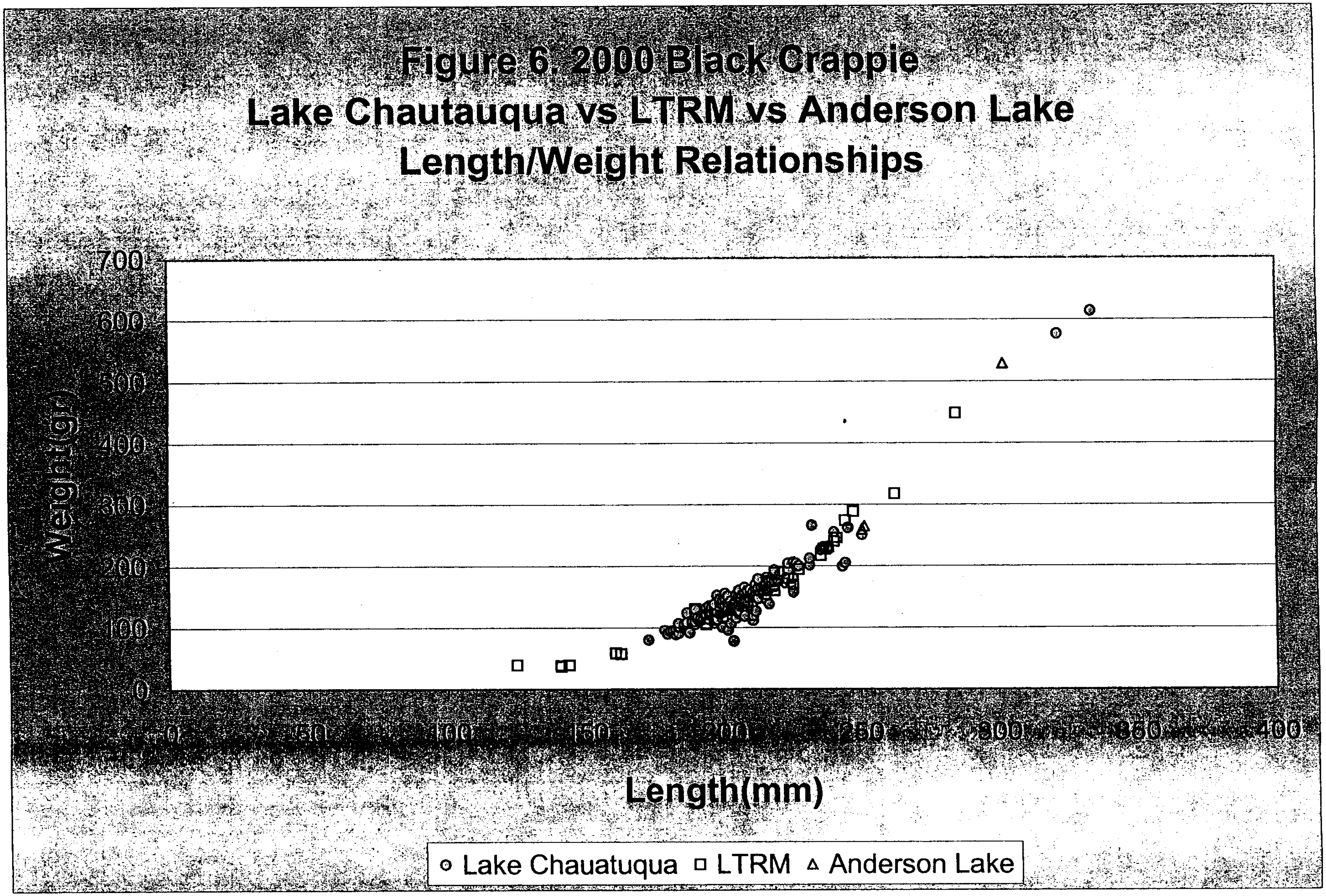


Figure 6. 2000 Black Crappie
Lake Chautauqua vs LTRM vs Anderson Lake
Length/Weight Relationships
Weight(gr)
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
Length(mm)
Lake Chauatuqua
LTRM
Anderson Lake

Figure 7. 2000 Lake Chautauqua
Largemouth Bass Length Distribution

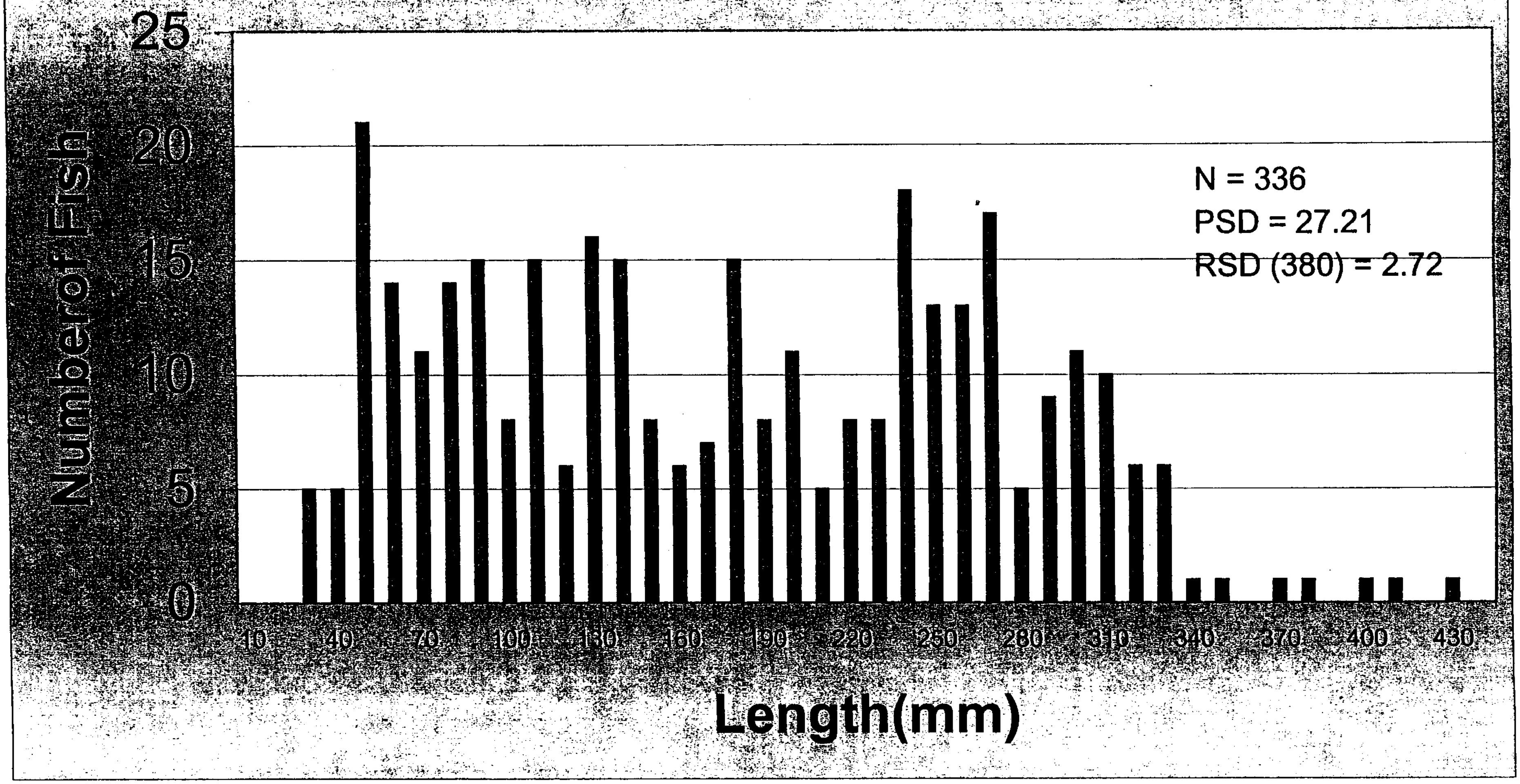


Figure 8. 2000 Largemouth Bass
Lake Chautauqua vs LTRM vs Anderson Lake
Length/Weight Relationships

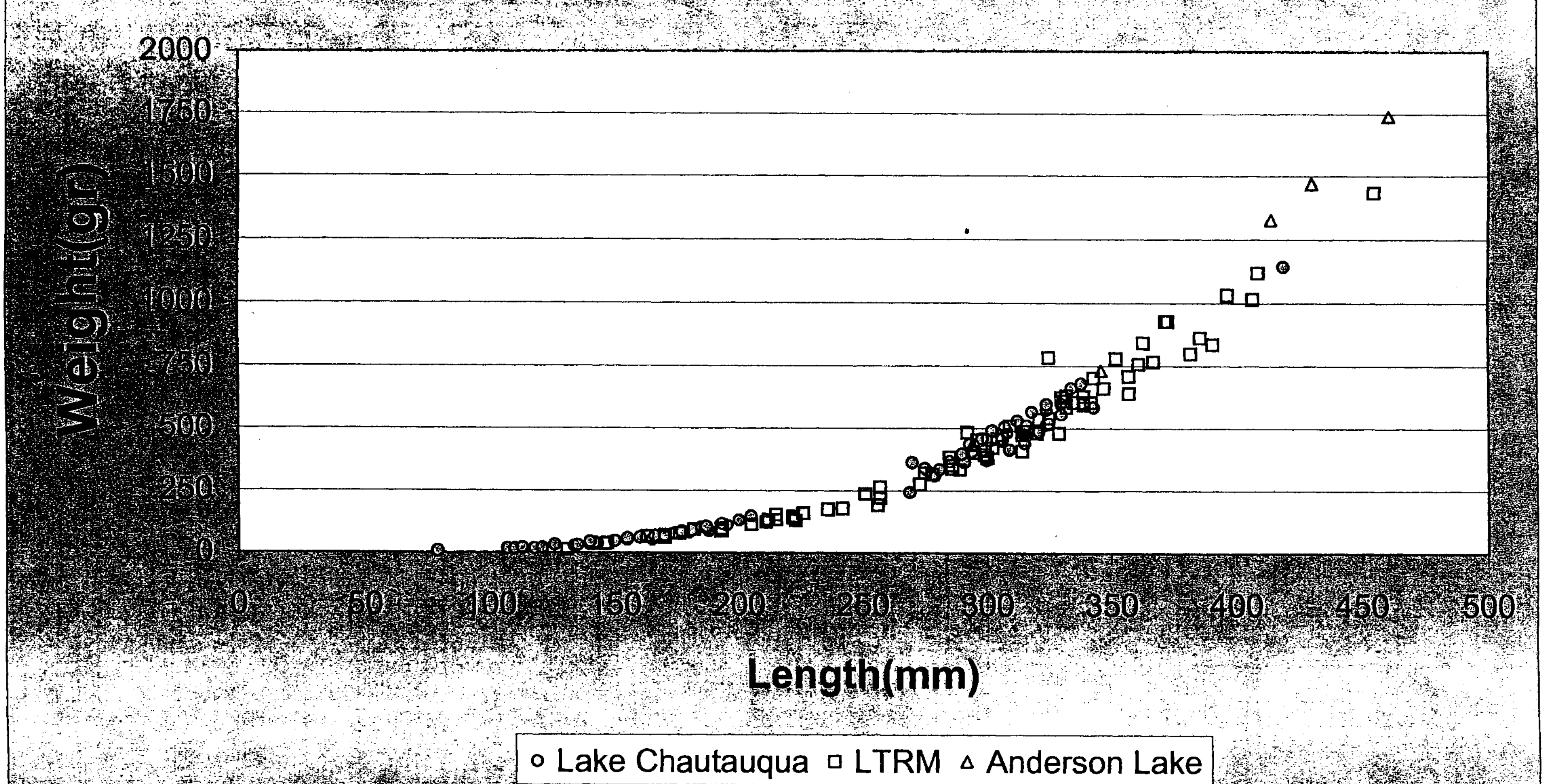


Figure 9. 2000 Lake Chautauqua Channel Catfish Length Distributions

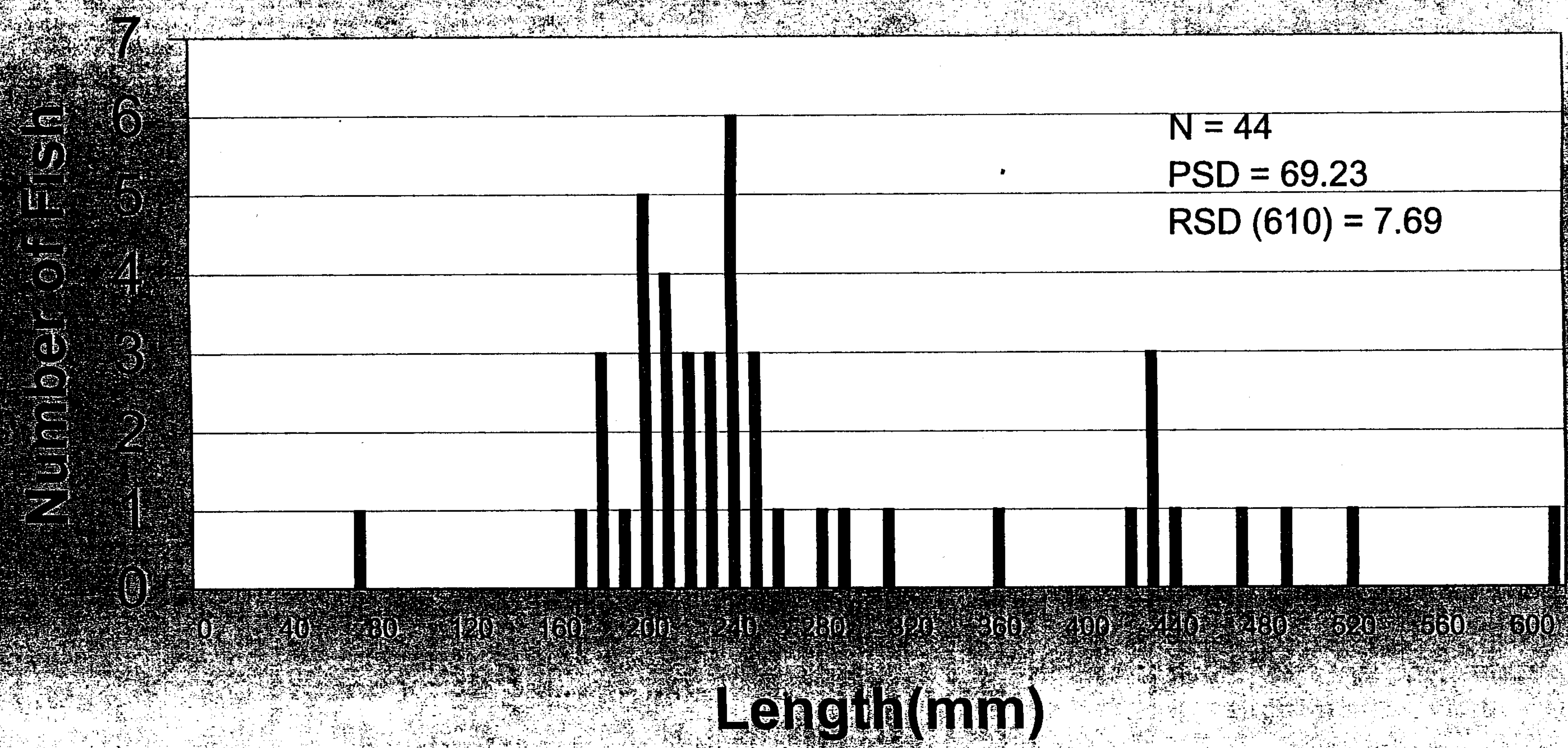


Figure 10. 2000 Lake Chautauqua Gizzard Shad Length Distribution

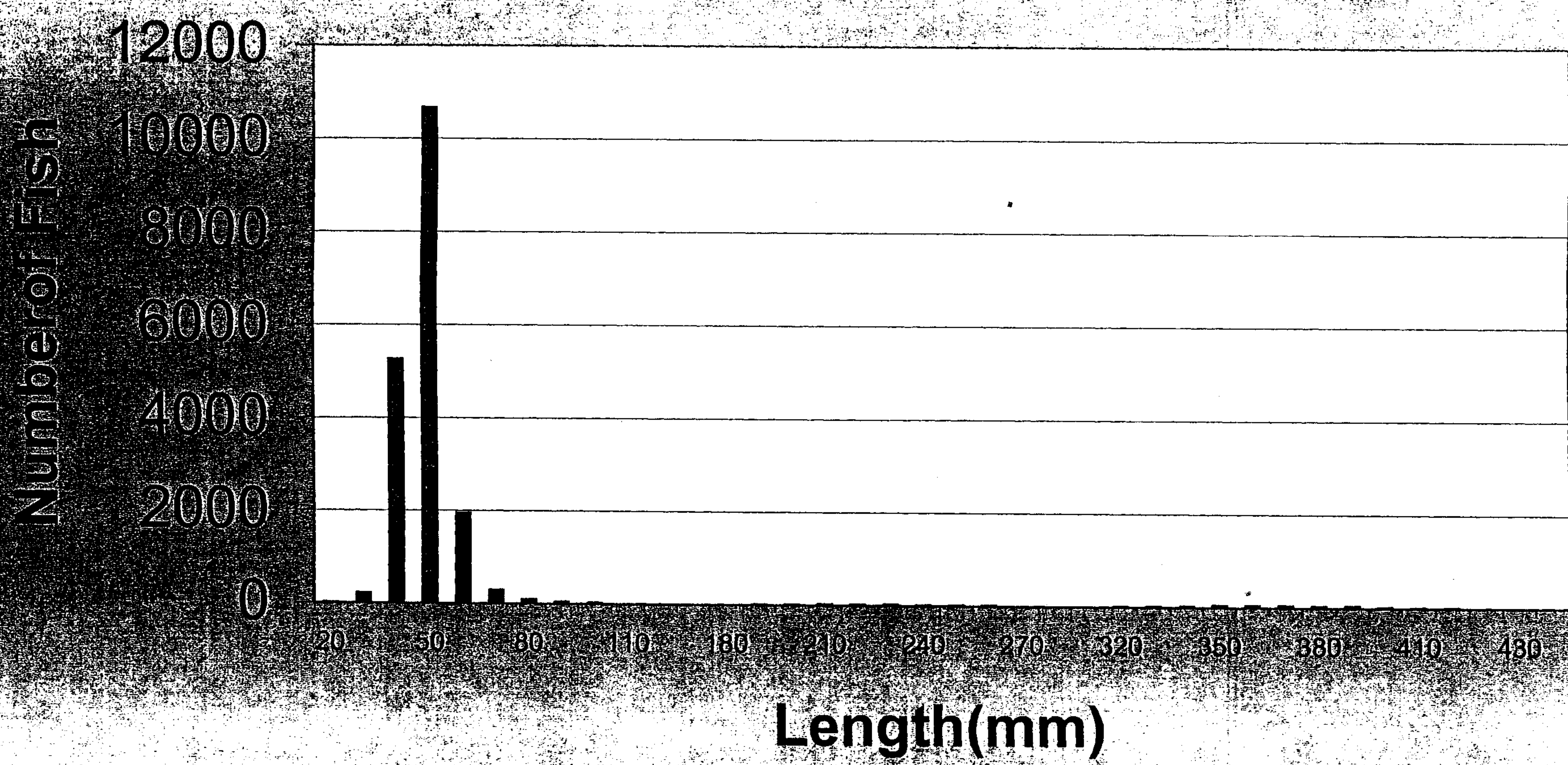


Figure 11. 2000 Lake Chautauqua Common Carp Length Distribution

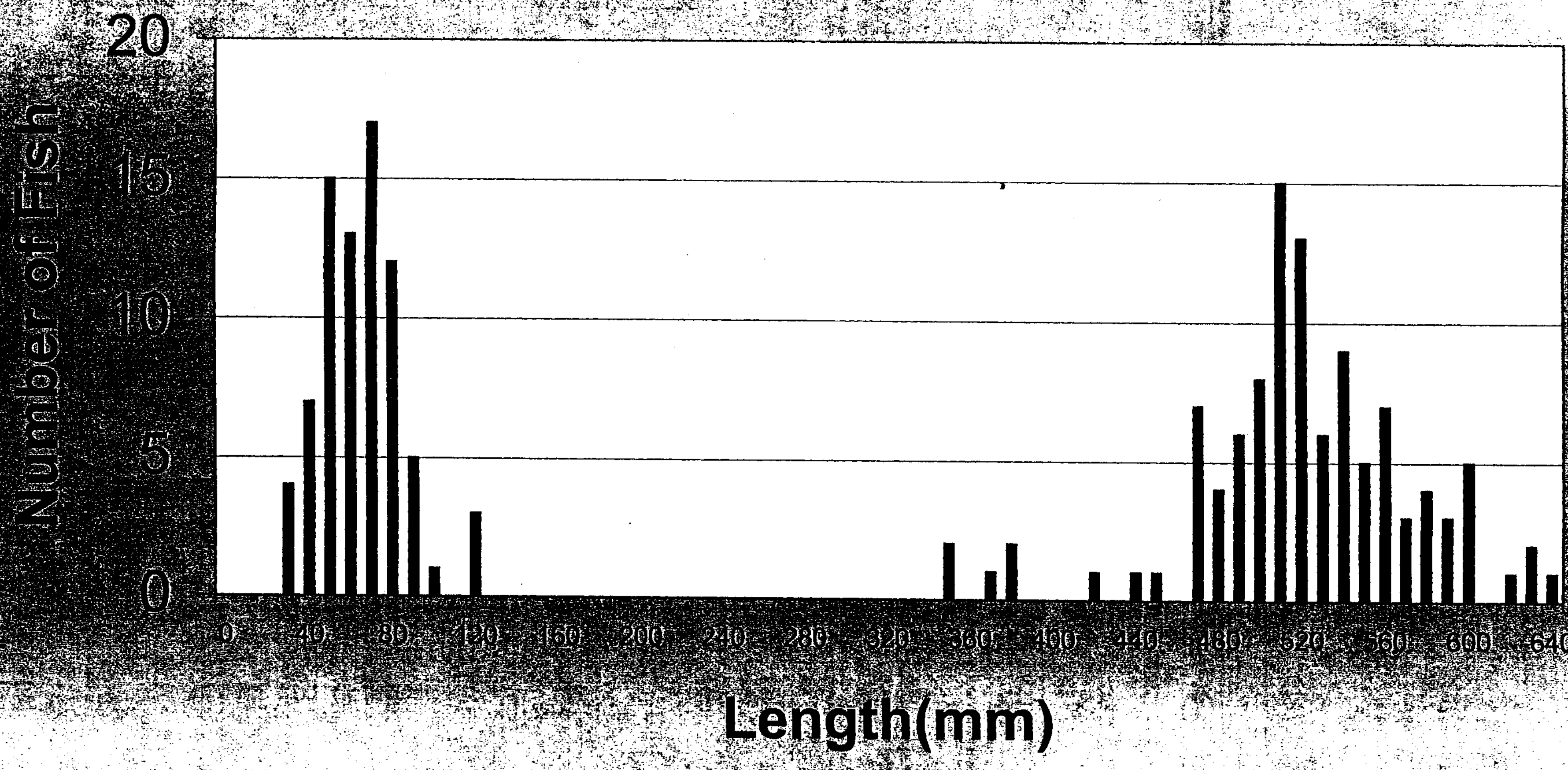


Figure 12. 2000 Lake Chatauqua
White Crappie Length Distribution

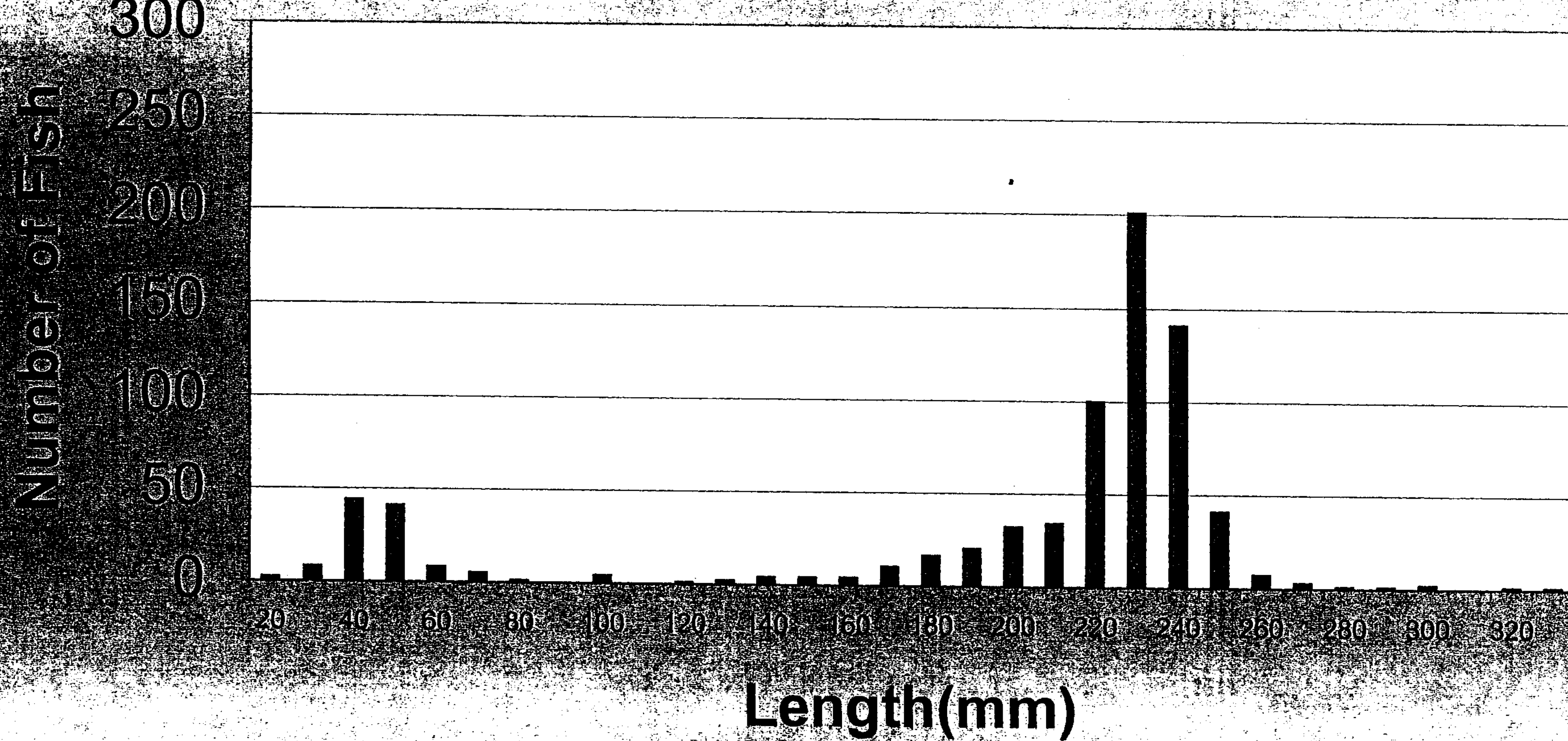


Figure 13. 2000 Lake Chautauqua
Freshwater Drum Length Distributions

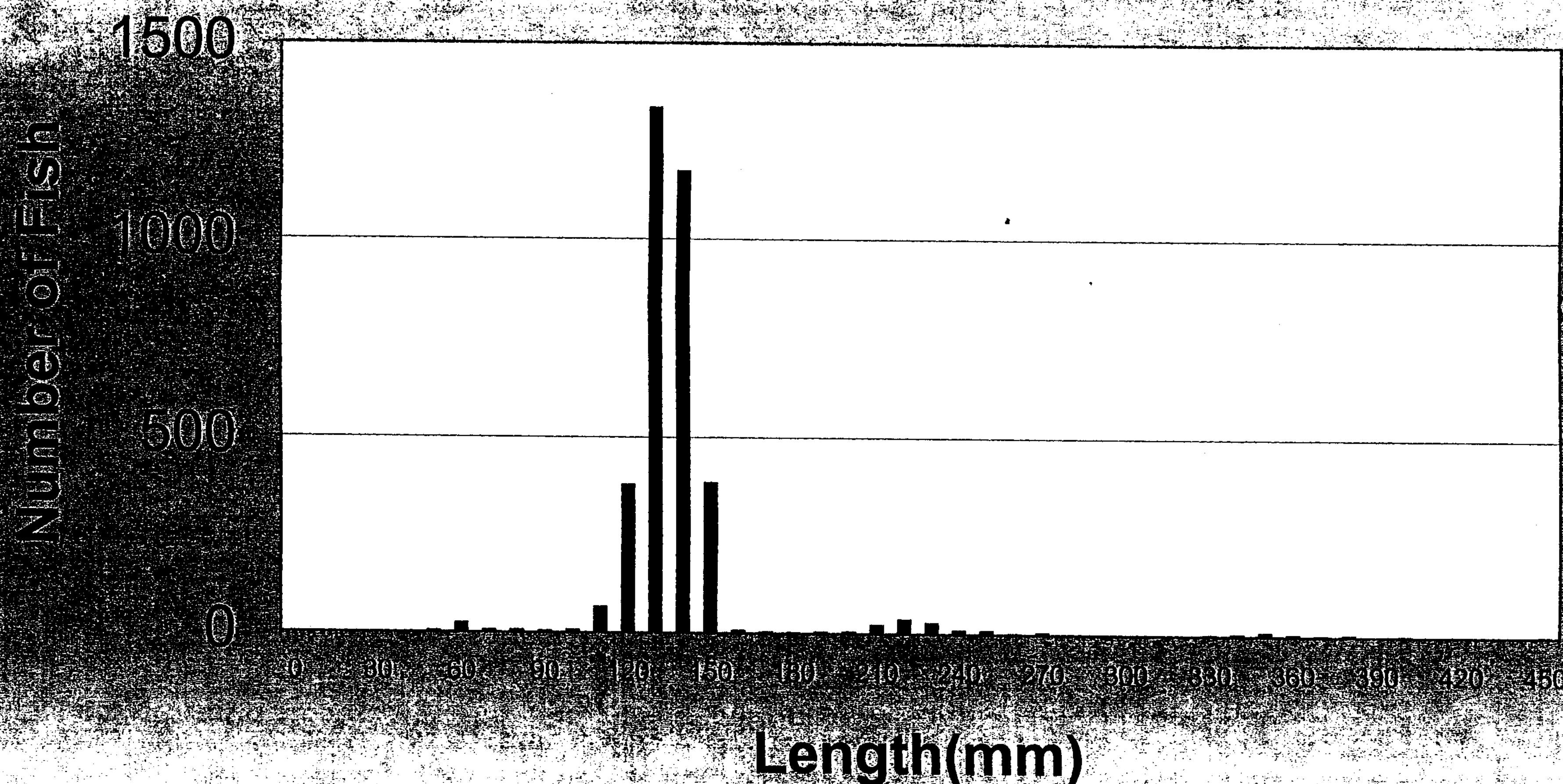


Figure 14. 2000 Lake Chautauqua White Bass Length Distributions

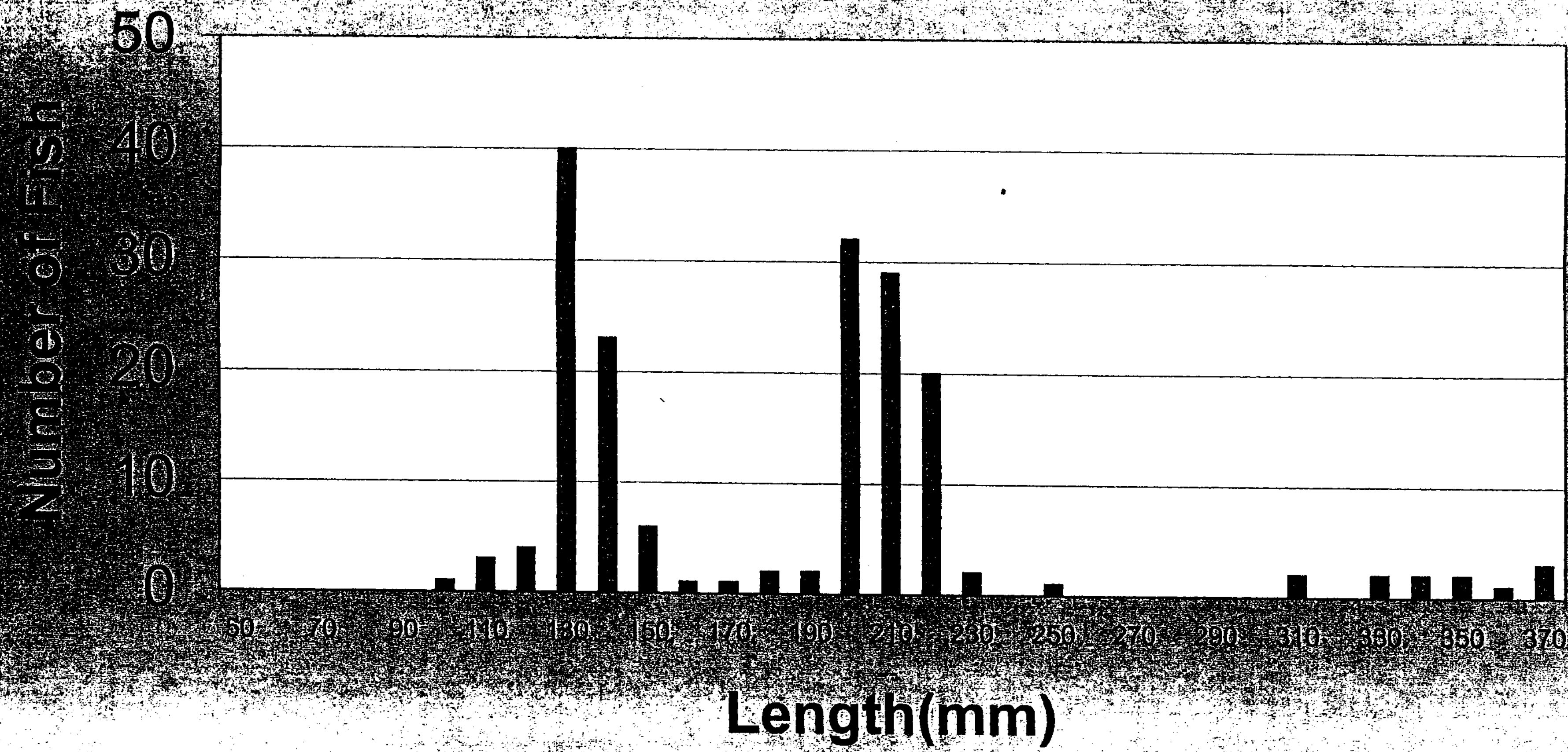


Figure 15. 2000 Lake Chautauqua water quality data collected by LTRM staff and Daily & Associates.

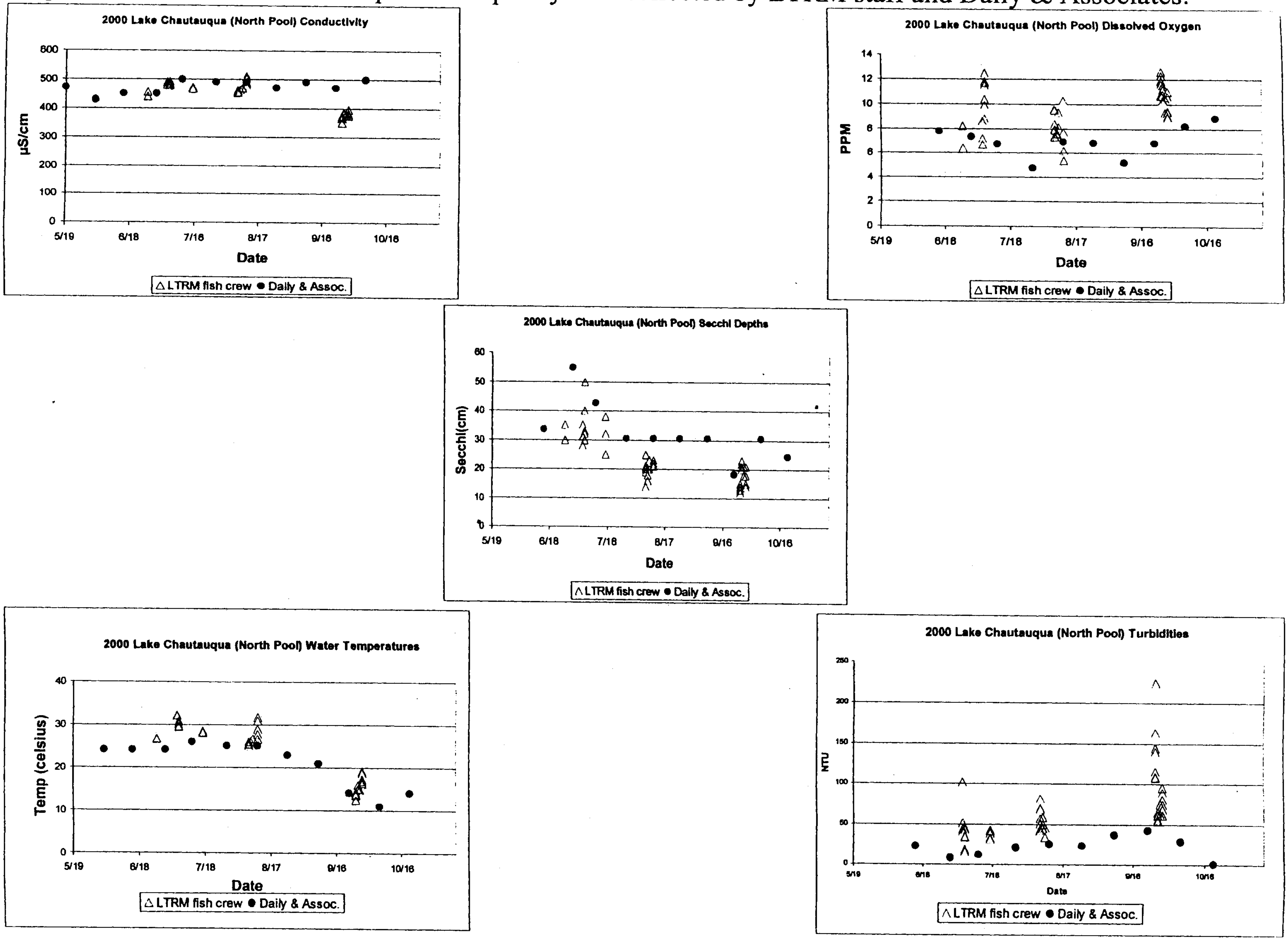


Table 2. Catch-per-unit-effort (CPUE) for north pool of Lake Chautauqua during 2000 sampling.

		BACKWATER ISOLATED OPEN WATER				BACKWATER ISOLATED Shoreline				
		GILL NETTING		DAY ELECTROFISHING		FYKE NETTING		MINNOW FYKE NETTING		
FISH SPECIES		Total Fish	CPUE	Total Fish	CPUE	Total Fish	CPUE	Total Fish	CPUE	TOTAL FISH
Bullhead minnow	*Pimephales vigilax*		0.00	139	7.72		0.00	171	9.50	310
Black bullhead	*Ameiurus melas*		0.00		0.00	1	0.06		0.00	1
Black crappie	*Pomoxis nigromaculatus*	3	0.50	66	3.67	1082	60.11	54	3.00	1205
Bluegill	*Lepomis macrochirus*	14	2.33	569	31.61	1240	68.89	729	40.50	2552
Bigmouth buffalo	*Ictiobus cyprinellus*	23	3.83	1	0.06	1	0.06		0.00	25
Brown bullhead	*Ictiobus niger*	5	0.83		0.00	13	0.72		0.00	18
Bowfin	*Amia calva*		0.00		0.00	3	0.17		0.00	3
Common carp	*Cyprinus carpio*	35	5.83	124	6.89	16	0.89	9	0.50	184
Channel catfish	*Ictalurus punctatus*	41	6.83	2	0.11	1	0.06		0.00	44
Emerald shiner	*Notropis atherinoides*		0.00	2	0.11		0.00		0.00	2
Freshwater drum	*Aplodinotus grunniens*	251	41.83	41	2.28	3196	177.56	31	1.72	3519
Goldfish	*Carassius auratus*		0.00	1	0.06	1	0.06		0.00	2
Golden shiner	*Notemigonus crysoleucas*		0.00	62	3.44		0.00	3	0.17	65
Green sunfish	*Lepomis cyanellus*		0.00	68	3.78	20	1.11	30	1.67	118
Gizzard shad	*Dorosoma cepedianum*	294	49.00	14760	820.00	1	0.06	3782	210.11	18837
Largemouth bass	*Micropterus salmoides*	4	0.67	306	17.00	22	1.22	4	0.22	336
Western mosquitofish	*Gambusia affinis*		0.00	3	0.17		0.00	4	0.22	7
Orangespotted sunfish	*Lepomis humilis*		0.00	38	2.11	9	0.50	17	0.94	64
Red shiner	*Cyprinella lutrensis*		0.00	2	0.11		0.00		0.00	2
Redear sunfish	*Lepomis microlophus*		0.00		0.00	1	0.06		0.00	1
River carpsucker	*Carpiodes carpio*	1	0.17	2	0.11	5	0.28		0.00	8
Sauger	*Stizostedion canadense*	1	0.17		0.00		0.00		0.00	1
Shorthead redhorse	*Moxostoma macrolepidotum*		0.00		0.00	1	0.06		0.00	1
Smallmouth buffalo	*Ictiobus cyprinellus*	3	0.50	1	0.06	6	0.33		0.00	10
Shortnose gar	*Lepisosteus platostomus*	15	2.50		0.00	12	0.67	1	0.06	28
Spotted gar	*Lepisosteus oculatus*	3	0.50	1	0.06	2	0.11		0.00	6
Threadfin shad	*Dorosoma petenese*		0.00	4	0.22		0.00	1	0.06	5
Warmouth	*Lepomis gulosus*		0.00	2	0.11		0.00		0.00	2
White bass	*Morone chrysops*	104	17.33	11	0.61	65	3.61		0.00	180
White crappie	*Pomoxis annularis*	21	3.50	107	5.94	568	31.56	43	2.39	739
Yellow bullhead	*Ameiurus natalis*	4	0.67	7	0.39	26	1.44	4	0.22	41
Yellow bass	*Morone mississippiensis*		0.00	4	0.22	2	0.11	1	0.06	7
HYBRIDS FISH SPECIES										
Goldfish X Common carp	*Carassius X C. Carpio*		0.00	3	0.17	1	0.06		0.00	4
Green sunfish X bluegill	*L. cyanellus X L. macrochirus*		0.00	1	0.06		0.00		0.00	1
UNIDENTIFIED FISHES										
Unidentified buffalo	*Unidentified Ictiobus sp.*		0.00	1	0.06		0.00		0.00	1
TURTLES										
Common Musk Turtle	*Sternotherus odoratus*		0.00		0.00	5	0.28		0.00	5
Red-eared Slider Turtle	*Trachemys scripta elegans*		0.00		0.00	12	0.67		0.00	12
Eastern Spiny Softshell Turtle	*Apalone mutica mutica*		0.00		0.00	2	0.11		0.00	2
Western Painted Turtle	*Chrysemys picta belli*		0.00	1	0.06	1	0.06	1	0.06	3
Grand Total		822	137.00	16329	907.17	6315	350.83	4885	271.39	28351

Table 3. Total abundances of fish collected during HREP bioresponse monitoring fish commuity sampling in Lake Chautauqua during 1991 - 2000.

		1991	1992	1993	2000
		8August-31December	1April-15June	13 May-1 June	15June-31October
Species					
Spotted gar	*Lepisosteus oculatus*			7	6
Longnose gar	*Lepisosteus osseus*			1	
Shortnose gar	*Lepisosteus platostomus*	3	49	149	28
Bowfin	*Amia calva*	1		3	3
Goldeye	*Hiodon alosoides*			4	
Skipjack herring	*Alosa chrysochloris*			1	
Gizzard shad	*Dorosoma cepedianum*	1,652	1,706	1,678	18,837
Threadfin shad	*Dorosoma petenese*	5	2	40	5
Goldfish	*Carassius auratus*		63	20	2
Red shiner	*Cyprinella lutrensis*			57	2
Common carp	*Cyprinus carpio*	35	282	428	184
Common carp X Goldfish	*Cyprinus carpio x auratus*		1	1	4
Silver chub	*Macrhybobsis storeriana*			5	
Golden shiner	*Notemigonus crysoleucas*		1		65
Emerald shiner	*Notropis atherinoides*	10	41	81	2
Spottail shiner	*Notropis hudsonius*	1			
Fathead minnow	*Pimephales promelas*			2	
Bullhead minnow	*Pimephales vigilax*		1	19	310
Creek chub	*Semotilus atromaculatus*		1		
River carpsucker	*Carpiodes carpio*	14	11	68	8
Quillback	*Carpiodes cyprinus*	6	4	8	
Highfin carpsucker	*Carpiodes velifer*			5	
Bigmouth buffalo	*Ictiobus cyprinellus*	4	82	52	25
Smallmouth buffalo	*Ictiobus cyprinellus*	3	26	24	10
Black buffalo	*Ictiobus niger*			4	
Shorhead redhorse	*Moxostoma macrolepidotum*	5	5	53	1
Black bullhead	*Ameiurus melas*	1	20	24	1
Yellow bullhead	*Ameiurus natalis*	3	19	13	41
Brown bullhead	*Ameiurus nebulosus*	55	193	151	18
Channel catfish	*Ictalurus punctatus*	1	7	22	44
Western Mosquitofish	*Gambusia affinis*		1	13	7
White bass	*Morone chysops*	233	98	37	180
Yellow bass	*Morone mississippiensis*	18	57	26	7
Green sunfish	*Lepomis cyanellus*	6	14	10	118
Warmouth	*Lepomis gulosus*			6	2
Orangespotted sunfish	*Lepomis humilis*		1	1	64
Bluegill	*Lepomis macrochirus*	368	542	235	2,552
Redear sunfish	*Lepomis microlophus*				1
Longear sunfish	*Lepomis megalotis*			1	
Green sunfish X Bluegill	*L. cyanellus x macrochirus*			3	1
Smallmouth bass	*Micropterus dolomieui*			1	
Largemouth bass	*Micropterus salmoides*	13	23	11	336
White crappie	*Pomoxis annularis*	80	80	14	739
Black crappie	*Pomoxis nigromaculatus*	212	122	60	1,205
Johnny darter	*Etheostoma nigrum*			1	
Yellow perch	*Perca flavescens*			1	
Logperch	*Percina caprodes*			4	
Sauger	*Stizostedion canadense*	3		4	1
Freshwater drum	*Aplodinotus grunniens*	1,921	622	201	3,519
Species count		25	28	43	32
			1hybrid	2 hybrid	2hybrid
Total fish		4,653	4,074	3,549	28,328

Chapter 3: Young-of-year fish escapement and diet composition from the South pool of Lake Chautauqua, 2000

A. Maria Lemke and James A. Stoeckel

Introduction

The South pool of Lake Chautauqua is a shallow, 940-ha floodplain lake on the La Grange Reach of the Illinois River near Havana, IL. Managed by the U.S. Fish and Wildlife Service as a moist soil unit to provide food and refuge for migrating waterfowl and shorebirds, it is annually flooded with river water from fall to early summer and subsequently dewatered during the summer. Additional interest pertaining to the suitability of Lake Chautauqua as habitat for young-of-year (YOY) fish has promoted a multi-year study to investigate the production and subsequent release of larval and juvenile fish into the Illinois River (Irons et al. 1997, Stoeckel et al. 1999a,b). One important component of habitat suitability assessment for young-of-year fish is the availability of edible plankton. An additional consideration for managed floodplain lakes is how the timing of dewatering events affects survivorship of larval and juvenile fish released into the river. Because zooplankton production is typically lower in rivers than lakes, fish produced in Lake Chautauqua may exhibit lower survivorship in the river system if they have not yet shifted their reliance from zooplankton as a primary food resource to fish and/or macroinvertebrates.

Specific objectives for 2000 were to estimate the number of young-of-year fish produced and released into the Illinois River from Lake Chautauqua, and compare diet composition among several fish taxa in order to (1) gain insight into diet overlap at the larval and juvenile stages, (2) determine the size ranges at which piscivorous fish species shift dietary habits from zooplankton to macroinvertebrates and fish, and (3) investigate the utilization of *Daphnia lumholtzi* (an exotic cladoceran) by larval and juvenile fish. Low zooplankton abundances in the Illinois River compared to Lake Chautauqua suggest that YOY fish produced in Lake Chautauqua will have higher survivorship in the Illinois River if they can utilize larger invertebrates and fish as food resources, rather than depend on zooplankton as a primary food source. An earlier study from Lake Chautauqua showed that high abundances of *D. lumholtzi* can occur from mid- to late-summer when river water levels exceed levee height of Lake Chautauqua for extended periods of time (Stoeckel et al. 1999b). Although the large spines produced by *D. lumholtzi* have been hypothesized to lower its value as a fish food resource, it could provide an alternate prey item during late summer when native zooplankton abundances in Lake Chautauqua are reduced (Stoeckel et al. 1999a,b).

Methods

Water quality

Water temperature and dissolved oxygen readings were recorded from Lake Chautauqua at the control structure on each sampling date. All readings were collected 0.25m below the water surface using a YSI model 55. The control structure consists of 4 gates that are approximately 1.5 m wide, and has been described in detail by Irons et al. (1997).

Larval fish

Fish were collected from the effluent of Lake Chautauqua using a standard LTRMP small-mesh hoop net (HN; 1.2 m in diameter) lined with 3-mm nylon netting, and a 500-µm mesh ichthyoplankton net (IN). Illinois River water level fluctuations resulted in multiple draw-down periods, designated as: early- (12-22 May), mid- (30 May -1 June, 8-15 June), and late- (25 July - 3 August) summer (Fig. 1). Zooplankton and YOY fish were collected daily from the south control structure of Lake Chautauqua during each of these drawdown periods. Five replicate HN and IN samples were collected on each sample date. For each replicate sample, the nets were set in the effluent for a 1 to 10-min period; 1 minute when flows and fish catches were high, and up to 10 minutes when flows and catches were low. Fish were anesthetized with alka-seltzer and samples were preserved in 10% buffered sugar formalin. In the laboratory, fish were enumerated and identified to lowest taxonomic level (Auer 1982, Hogue et al. 1976, May and Gasaway 1967). Total length of YOY fish were measured using image analysis and gut contents of selected taxa were identified and numerically quantified under a dissecting microscope.

Flow meters were used to determine the amount of water sampled by each net. To estimate the volume of water sampled, we used General Oceanics digital flowmeters (Model 2030, General Oceanics, Inc., Miami FL) mounted in the center of each net. The volume of water sampled by each net was calculated using the following formula:

$$\text{Volume (m}^3\text{)} = A*(2.687*r*0.01),$$

where A=area of net opening in m^2, 2.687=constant from flowmeter, r=number of revolutions from flowmeter, and 0.01=conversion factor to m^3. The total number of fish caught was divided by the total volume of water sampled to yield an estimate of the number of fish/m^3 water sampled that were collected.

Estimates of the total numbers of fish escaping from the South pool were calculated separately for ichthyoplankton and hoop nets on each for each escapement period. Using the difference in gauge heights between successive sampling dates, we calculated the volume drained from the South pool using volume data obtained from Jim Rogala (NBS-EMTC, data from GIS coverage). This data estimates that at a water surface elevation of 435 ft, the surface area of the south pool is 8,142,000 m^2 (see Stoeckel et al. 1999a). The volume of water exiting the South pool was estimated between sampling dates by multiplying the difference in gauge height (m) on successive dates by the total surface area of the South pool at elevation of 435 ft (9,544,000 m^2). Fish collections (#/m3) on 2 consecutive dates were averaged and multiplied by the volume of water drained between the dates to obtain an estimate of fish escapement. A transition period occurred during 3 separate days of mid-escapement in which water flowed in and out of the South pool. Ichthyoplankton samples were collected during this time and data was used in size-frequency and percent composition analyses. These samples were not included, however, in calculations of total fish exiting into the Illinois River. Although we estimated the number of fish that exited from the South pool of Lake Chautauqua (see App. A), we cannot verify that these same numbers were actually produced in the Lake Chautauqua (and not in Quiver Lake) because of the frequency of water entering the South pool from Quiver Lake during high water periods (see Fig. 1).

Zooplankton

Zooplankton were collected using a hand-operated diaphragm pump. Three zooplankton samples were collected on each sampling date by concentrating 30 L of pumped lake water onto a 55-µm mesh sieve. Each sample rinsed into a collection vial, anesthetized with alka-seltzer to reduce egg loss, and preserved with 10% buffered sugar formalin. Zooplankton were enumerated and identified using a dissecting microscope under 50X magnification. Copepods were identified to order (i.e., cyclopoida, calanoida), but were combined for statistical analyses. Copepod nauplii were treated as a separate taxonomic group. Cladocerans and rotifers were identified to genus, using Hebert (1995), Pennak (1978), and Edmondson (1959). For each sample, 5-ml subsamples were examined until either 100 individuals of the most common taxa or 60% of the sample had been counted.

Results

Escapement

Water temperature at the control structure fluctuated on a daily basis, however, increased from 18°C to 28°C during the entire escapement period (Fig. 2). Dissolved oxygen (DO) levels remained steady (5-7 mg/L) for much of the sampling period, although several days of high DO levels were recorded near the end of May (10-15 mg/L) and in early June (9 mg/L). Dissolved oxygen levels tended to decline during the end of the sampling period and reached levels <2.0 mg/L by the last sampling day (Fig. 2).

At least 21 species from 8 families were identified during escapement sampling (App. A). Quantitative catch (no. fish/m^3 water sampled) decreased over time in the ichthyoplankton nets, and increased in the hoop nets (Fig. 3). Clupeids were the dominant taxon collected during the overall escapement period in ichthyoplankton and hoop nets (Fig. 3). Relative abundances of clupeids collected from ichthyoplankton nets decreased from 93% during early-summer escapement to 66% during late-summer escapement as centrarchids, common carp, grass carp, and bighead carp abundances increased. In the hoop net samples, relative abundances were more evenly distributed among several taxa, including: clupeids, percichthyids, carp species, emerald shiners, freshwater drum, other cyprinids, percidae, bluegill, crappie and other centrarchids. Similar to the ichthyoplankton net samples, the relative abundances of bighead and grass carp increased during late-summer escapement. Other taxa collected during the 2000 escapement period included catostomids, largemouth bass, and ictalurids (Appendix A).

Larval fish collected in ichthyoplankton nets during early and mid-escapement were primarily <30 mm, whereas those collected during late-escapement ranged from 10-99 mm (Figs. 4-9). Hoop net size frequency patterns were similar for shad (Fig. 4), white bass (Fig. 5), bluegill (Fig. 6), and drum (Fig. 7) in which a few large individuals (>100mm) were collected during early escapement, followed by large numbers of small (<20 mm) and mid-sized (≥20 mm) individuals during mid- and late-escapement, respectively. Total length distributions remained very similar between early and mid-escapement for these 4 families; however, length frequency mode increased between mid- and late-escapement for most taxa.

Clupeid length frequency mode increased from <10 and 20 mm to 50 mm in ichthyoplankton and hoop net samples during mid- and late-escapement periods, respectively (Fig. 4). Clupeids collected in hoop nets were primarily gizzard shad (*Dorosoma cepedianum*), however, threadfin shad (*D. petenense*) and skipjack herring (*Alosa chrysochloris*) were also collected (Fig. 4, App. A). Length frequency mode of white bass increased from <10 and 20 mm to 80 mm in ichthyoplankton and hoop net samples during mid- and late-escapement periods, respectively (Fig. 5). White bass were collected in greatest numbers in ichthyoplankton nets (<10 mm) and hoop nets (80-99 mm) during mid- and late-escapement, respectively. Centrarchid length frequency mode also increased from mid- (0-9mm and 30) to late- (60 mm) escapement in ichthyoplankton and hoop net collections (Fig. 6), however, the range of size classes for centrarchids collected in ichthyoplankton (0-89mm) and hoop nets (20-150mm) was greater than for clupeids and percichthyds collected during late-escapement. Total catch decreased between mid- and late-escapement in ichthyoplankton nets and increased in hoop nets, similar to the pattern observed for clupeid and percichthyd collections. Centrarchid size distributions between 0 and 80 mm were similar in ichthyoplankton and hoop nets during late-escapement, however, small numbers of fish <100 mm were also collected in hoop nets throughout the entire escapement period. Bluegill and white crappie were the primary centrarchid species collected during early and mid-escapement, whereas black crappie and largemouth bass were more abundant in late-escapement collections.

No cyprinids were collected during early escapement in the ichthyoplankton nets (Fig. 8). The size frequency mode increased from 0-9 mm in mid-escapement, dominated by small cyprinids, minnows, and common carp to 60 mm during late-escapement, dominated by grass and bighead carp. Hoop net length frequency modes remained similar throughout escapement period (60-70 mm), however, species composition changed from minnow dominated collections in early- and mid-escapement to grass and bighead carp dominated collections during late-escapement. No freshwater drum were collected in ichthyoplankton nets during late escapement, and only individuals <10 mm were collected during early and mid-escapement (Fig. 7). Very few freshwater drum were collected in hoop nets during the entire escapement period (n=21), and sizes ranged from 10 to 260 mm. Catostomid sizes ranged from 0 to 40 mm in ichthyoplankton nets and 20 to 110 mm in hoop nets (Fig. 9). Very few individuals were collected during the escapement period (n=73), and no catostomids were collected either in late-escapement ichthyoplankton nets or early-escapement hoop nets.

Zooplankton

Zooplankton composition in the escapement samples were numerically dominated by rotifers, and to a lesser extent, copepod nauplii (Fig. 10). Cladocerans, copepods, and ostracods comprised a very small percent of total zooplankton abundances throughout the escapement period. The mesh size used to collect zooplankton in this study (55-μm) probably underestimated abundances of smaller rotifer species. Of the rotifers collected, *Keratella cochlearis* and *Branchionus angularis* were the 2 most abundant rotifers collected (Fig. 11), each comprising ≈35% total rotifer abundances during the escapement period. *K. cochlearis* was abundant during early- and mid-escapement and was replaced by *Branchionus* during mid- and late-escapement. *Polyartha* was consistently present throughout the escapement period and comprised ≈7% of total rotifer abundances during escapement. *Keratella quadrata* comprised ≈12% of total rotifer abundances during escapement, but were abundant only during the mid-escapement period. Total copepod abundances were dominated by nauplii throughout the entire sampling period (Fig. 12). Of the identifiable copepods, cyclopoids occurred in higher abundances than calanoids throughout the entire escapement period. Ostracods were consistently collected in low numbers throughout the sampling period (Fig. 12). Cladoceran abundances were dominated by the exotic daphniid, *Daphnia lumholtzi*, and other native daphniid species throughout the sampling period (Fig. 13). Native *Daphnia* spp. exhibited high abundances during early escapement and were replaced by high numbers of *Daphnia lumholtzi* during mid- and late escapement periods. *Bosmina* were most abundant during early and mid-escapement and were replaced by *Moina* and high abundances of *Diaphanosoma* during late-escapement. Other cladoceran taxa included *Ceriodaphnia*, *Simocephalus*, *Scapholeberis*, *Leptodora*, *Chydorus*, *Alona*, *Kurzia*, *Eurycercus*, *Pleuroxus*, and *Ilyocryptus*. Other rotifer taxa collected were *Asplanchna*, *Branchionus calyciflorus*, *B. urceolaris*, *B. caudatus*, *B. quadridentata*, *Filinia*, *Synchaeta*, *Lecane*, *Notholoca*, *Platyias patulus*, *P. quadricornis*, *Cephalodella*, and *Trichotria*.

Fish diet composition

Clupeid larvae between 0 and 24 mm fed on a similar diet of small-bodied invertebrates including rotifers, microcrustacean eggs, cyclopoid and naupliar copepods, cladocerans, and ostracods (Fig. 14). In contrast, the diets of larval white bass (0-20mm) and freshwater drum (0-10mm) were comprised almost exclusively of cyclopoid copepods and microcrustacean eggs. Whereas white bass <20 mm in total length primarily consumed zooplankton, juveniles 60-100 mm consumed mostly insects and at total lengths >100 mm began ingesting fish as prey (Fig. 15). Based on diet analysis, white bass were determined to be zooplanktivorous at total lengths <20mm, insectivorous from 60-100mm, and piscivorous at sizes >100mm (Fig. 16). No fish between 20 and 59mm were collected during this study, although it is sometime during this size range that white bass undergo the transition from consuming zooplankton to insects. *Daphnia lumholtzi* were consumed by several juvenile fish species (white bass, largemouth bass, emerald shiners) and comprised a significant proportion (46%) of prey items contained in juvenile bluegill diets between the sizes of 41 and 63mm (Figs. 15, 17). Emerald shiners (57-74mm) consumed a variety of prey items including microcrustacean eggs and ephippia, *D. lumholtzi*, adult insects and mites. Numerically, corixids comprised a large proportion of largemouth bass diet (56-89mm), although individuals between 72 and 89 mm also ingested fish.

Discussion

Escapement.- High abundances of bighead and grass carp in 2000 escapement samples reinforce previous reports that Lake Chautauqua may serve as spawning habitat for these recently established exotic species (Stoeckel et al. 1999a). Bighead carp were first reported from Lake Chautauqua in 1997 (Stoeckel et al. 1999a) in which 2 individuals were collected during a 10-d escapement period (24 June-5 July), and were estimated to represent 955 bighead carp produced and released from Lake Chautauqua into the Illinois River. Catch data for bighead carp from the La Grange Reach of the Illinois River (near Peoria, IL) increased by 2 orders of magnitude during 2000, indicating that bighead carp populations have increased dramatically in the Illinois River since 1997 (Chick and Pegg 2001, LTRMP unpublished data). Data from a recent study by Shrank et al. (2001) suggests that spawning occurs in conjunction with increased discharge after water temperatures exceed >22°C. Thus, during years with late summer flooding, managed backwater areas such as Lake Chautauqua may serve as ideal spawning grounds for the production and ultimate release of bighead carp into the Illinois River (Pegg et al., in review). Only 1 adult grass carp was collected from Lake Chautauqua during 1996 (Irons et al. 1997) and 1997 (Stoeckel et al. 1999a); however, when final analyses of larval and juvenile collections were concluded, >60,000 YOY grass carp were estimated to have been produced and released from Lake Chautauqua during 1997 (Stoeckel et al. 1999a). Although the frequent reversal of water flow between Quiver Lake and Lake Chautauqua prevents us from estimating the number of bighead and grass carp that were produced in Lake Chautauqua, the number of individuals released during the late escapement period represented 17% and 22% of the total fish collected during that period in ichthyoplankton and hoop nets, respectively (Fig. 3).

Results from 2000 escapement are consistent with previous reports in which production and release of forage fish (clupeids, cyprinids) from Lake Chautauqua has been higher than that of commercially harvested (e.g., buffalo, common carp) and sport fish (e.g., centrarchids, white bass, drum) species (Irons et al. 1997, Stoeckel et al. 1999a,b). In the current study, clupeids comprised 48-93% of total escapement (Fig. 3) compared to 55% in 1996 (Irons et al. 1997) and 71-78% in 1997 (Stoeckel et al. 1999a). Only 73 individual catostomids were collected during 2000 escapement, representing <1.0% of the YOY fish collected during the entire 2000 escapement period. Similarly catostomids represented <1.0% of the escapement catch during 1997 (Stoeckel et al. 1999a). During 1997, sport fish (i.e., centrarchids, white bass) represented 1% of total escapement numbers (Stoeckel 1999a). Data from 2000 escapement cannot be directly compared to that of 1997, in which water continually flowed out of Lake Chautauqua into Quiver Lake (Stoeckel et al. 1999a). However, results from the current study indicate that centrarchids comprised the greatest percentage of the estimated total fish exiting Lake Chautauqua during mid-escapement (10.2% and 1.0% in ichthyoplankton and hoop nets, respectively). White bass generally comprised <2% of the fish estimated to have been released from Lake Chautauqua into the Illinois River during 2000.

Diet analysis.- Diet analysis from escapement sampling is somewhat limited because fish and zooplankton samples collected during escapement do not represent their distribution in the lake, and thus the actual availability of zooplankton to YOY fish cannot be quantified. Additional limitations occurred in the case of this study, because certain size classes of fish were not collected during non-escapement periods (Figs. 15, 16). However, results from diet analyses suggest that larval shad, white bass, and freshwater drum exhibited various levels of selectivity for cyclopoid copepods. High percentages of cyclopoids were consumed by clupeid larvae compared to their relative abundances in the zooplankton escapement; although, similarly high percentages of copepod nauplii and rotifers comprising clupeid diets and zooplankton escapement suggest that larval clupeids (≤24 mm) also feed on the variety of zooplankton that are available to them (Figs. 14, 10). Other studies have shown that rotifers and copepod nauplii often occur in diets of YOY gizzard shad (Dettmers and Stein 1992, DeVries and Stein 1992). Several cladocerans were consumed by larval clupeids (native Daphnia spp., *Bosmina*, *Diaphanosoma*, and *Leydigia*) and comprised a smaller percentage of clupeid diets than other prey items. Although previous research has shown that small gizzard shad (5-17mm) prefer copepods over cladocerans (Dettmers and Stein 1992), selectivity cannot be calculated directly from escapement samples. However, future research will include sampling larval fish and zooplankton simultaneously in Lake Chautauqua, and will permit more in depth diet analysis. In contrast to clupeids, larval white bass (≤20mm) and freshwater drum (≤10mm) consumed only cyclopoid copepods and microcrustacean eggs, suggesting they were highly selective for cyclopoid copepods over other more dominant taxa (i.e., rotifers, nauplii). High numbers of microcrustacean eggs consumed by many species of larval and juvenile fish are surprising and will require further research.

Clupeid diet composition was more similar among dates than within each designated size class (Fig. 14). As clupeids increase in size, they may not necessarily select for larger prey but may continue to feed on smaller zooplankton size classes (Bremigan and Stein 1994). In contrast, our data indicates that white bass did increase the size of their prey items over time, switching from small cyclopoids and zooplankton eggs during the larval stage (0-20mm) to larger zooplankton taxa (e.g., calanoids, *D. lumholtzi*) and insects (corixids, chironomids) at sizes 60-100mm, and to fish and insects at sizes >100mm (Figs. 15, 16). Ontogenetic diet shifts have been well-documented among centrarchid species (Welker et al. 1994, Bremigan and Stein 1994) and was observed to some extent in largemouth bass in Lake Chautauqua (Fig. 17). Largemouth bass 56-65mm were primarily insectivorous, whereas those >72mm also consumed fish as prey. According to our diet analysis data, 98% of the white bass were still <20mm and highly dependent on zooplankton as late as mid-June, and the transition to piscivory did not occur among white bass and largemouth bass juveniles until late-summer (Figs. 15-17). If survivorship of YOY fish in the Illinois River is lower when they are still dependent on zooplankton as their primary food resource, the survival of larval white bass and largemouth bass in the river system will be predictably higher when dewatering occurs later in the summer.

Zooplankton.- High abundances of rotifers and nauplii in escapement collections indicate that Lake Chautauqua was dominated by these small-sized zooplankton during 2000, as has been reported from previous sampling years (Stoeckel 1999a,b). These combinative results indicate that Lake Chautauqua provides an ideal foraging environment for gizzard shad, which exhibit strong selectivity for small zooplankton (Bremigan and Stein 1994) and typically consume rotifers and nauplii (Dettmers and Stein 1992, DeVries and Stein 1992, this study). However, fish species which selectively feed on larger-bodied zooplankton (e.g., bluegill, white bass, largemouth bass) may be somewhat resource limited in Lake Chautauqua during larval and juvenile stages. Diet analysis data indicate that rotifers and copepod nauplii were not utilized by centrarchids and white bass; however, *D. lumholtzi* were consumed by juvenile white bass, bluegill, and largemouth bass, as well as adult emerald shiners during mid and late summer (Figs. 15, 17). The high numerical percentage of *D. lumholtzi* in bluegill diets suggests that this cladoceran may be especially important to juvenile bluegill growth and survival. These results provide evidence that high abundances of *D. lumholtzi* in late summer may provide an additional food source for white bass and centrarchids during a time when they may be searching for larger zooplankton prey associated with ontogenetic shifts from zooplankton to macroinvertebrates and fish.

Successful colonization of *D. lumholtzi* in Lake Chautauqua appears to be dependent on hydrologic conditions of the Illinois River and the subsequent timing of escapement in the lake. High abundances of *D. lumholtzi* occurred during years in which mid summer flooding in the river delayed total dewatering of Lake Chautauqua until late July (Stoeckel 1999b, this study), whereas, low *D. lumholtzi* abundances were reported during an early escapement year (June 24-5 July, 1997; Stoeckel et al. 1999a). Thus, high water conditions in the river during mid summer prevent dewatering of the lake until late summer, which extends the inundation period of Lake Chautauqua and permits *D. lumholtzi* to colonize and reproduce. Similarly, *Diaphanosoma*, and *Moina* appear to rely on an extended inundation period to obtain high densities in Lake Chautauqua. These species are all common taxa in the Illinois River main channel (Stoeckel et al. 1996, J. A. Stoeckel, unpublished data), although it is unknown at this time whether they colonize Lake Chautuaqua directly from the river inflow or from preexisting ephippia associated with the lake sediments.

Management implications.- Most species of fish released during early- and mid-escapement were still within the size ranges in which they are reportedly very dependent on zooplankton for their growth and survival. By the mid-escapement period, only about 14% of the gizzard shad released were within the size range at which they become omnivorous (25-35 mm length; Yako et al. 1996) compared to nearly 100% of shad ≥40mm released during late-escapement (Fig. 4). Similarly, almost 100% of the bluegill (<40mm; Fig. 6) and freshwater drum (<20mm; Fig. 7) collected during early and mid-escapement consumed exclusively zooplankton (Figs. 17, 14). White bass were not captured in large numbers until mid- and late-escapement (Fig. 5) and were not large enough to switch food resources to macroinvertebrates and fish until late-escapement (Figs. 15, 16). Several other taxa (largemouth bass, black crappie) were not identifiably collected until late-escapement (Fig. 6), presumably because they were too small (<20mm) to be distinguished from other centrarchids during early- and mid-escapement. Abundance data suggest that Lake Chautauqua has the potential to be an important source of fish recruitment to the Illinois River. Additionally, diet analysis and data suggest that the YOY produced in the South pool will exhibit higher survival when they are released into the river later in the summer. However, the primary assumption of these recommendations that must be considered is that survivorship of YOY fish in the Illinois River is lower when they are still dependent on zooplankton for their primary food resource. Further investigations need to be conducted on the diet and survivorship of YOY size classes after they exit the South pool in order to assess the importance of Lake Chautauqua to overall fish recruitment in the Illinois River.

References

Auer, N. A., (ed.) 1982. Identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan drainage. Ann Arbor, MI: Great Lakes Fishery Commission, Spec. Publ. 82-3. 744 pp.

Bremigan, M. T., and R. A. Stein. 1994. Gape-dependent larval foraging and zooplankton size: implications for fish recruitment across systems. Can. J. Aquat. Sci. 51:913-922.

Chick, J. H., and M. A. Pegg. 2001. Invasive carp in the Mississippi River basin. Science 292:2250-2251.

Dettmers, J. M., and R. A. Stein. 1992. Food consumption by larval gizzard shad: zooplankton effects and its implications for reservoir communities. Trans. Am. Fish. Soc. 121:494-507.

DeVries, D. R., and R. A. Stein. 1992. Complex interactions among fish and zooplankton as influenced by an open-water planktivore. Can. J. Fish. Aquat. Sci. 49:1216-1227.

Edmondson, W. T. (ed.) 1959. Freshwater Biology, second edition. John Wiley and Sons, New York, USA.

Hebert, P. D. N. 1995. The *Daphnia* of North America – An illustrated fauna (CD). Dept. of Zoology, University of Guelph, Guelph, Ontario, Canada.

Hogue, J. J., Jr., R. Wallus, and L. Kay. 1976. Preliminary guide to the identification of larval fishes in the Tennessee River. Tennessee Val. Auth., Norris. Tech. Note B19. 66 pp.

Irons, K. S., P. T. Raibley, K. D. Blodgett, and R. E. Sparks. Progress Report: Lake Chautauqua Fish Production Study, 1996. Illinois Natural History Survey, Aquatic Ecology Technical Report 97/13. 59 pp.

May, B. B., and C. R. Gasaway. 1967. A preliminary key to the identification of larval fishes of Oklahoma, with particular reference to Canton Reservoir, including a selected bibliography. Okla. Fish. Res. Lab., Bull. No.5. 42 pp.

Pegg, M. A., A. M. Lemke, and J. A. Stoeckel. In review. Establishment of bighead carp in an Illinois River flooplain lake: a potential source population. Submitted to Journal of Freshwater Ecology.

Pennak, R. W. 1978. Freshwater Invertebrates of the United States. John Wiley and Sons. New York, USA.

Schrank, S. J., P. J. Braaten, and C. S. Guy. 2001. Spatiotemporal variation in density of larval bighead carp in the lower Missouri River. Trans. Am. Fish. Soc. 130:809-814.

Stoeckel, J. A., L. Camlin, K. D. Blodgett, and R. E. Sparks. 1996. Establishment of *Daphnia lumholtzi* (an exotic zooplankter) in the Illinois River. Journal of Freshwater Ecology 11:377-379.

Stoeckel, J. A., K. S. Irons, and T. E. Snider. 1999a. Progress Report: Lake Chautauqua Fish Production Study, 1997. USACE, 41 pp.

Stoeckel, J. A., K. S. Irons, K. C. Boggs, and B. Cross. 1999b. Progress Report: Lake Chautauqua Fish Production Study, 1998. Illinois Natural History Survey, Aquatic Ecology Technical Report 99/17. 32 pp.

Welker, M. T., C. L. Pierce, and D. H. Wahl. 1994. Growth and survival of larval fishes: roles of competition and zooplankton abundance. Trans. Am. Fish. Soc. 123:703-717.

Yako, L. A., J. M. Dettmers, and R. A. Stein. 1996. Feeding preferences of omnivorous gizzard shad as influenced by fish size and zooplankton density. Trans. Am. Fish. Soc. 125:753-759.

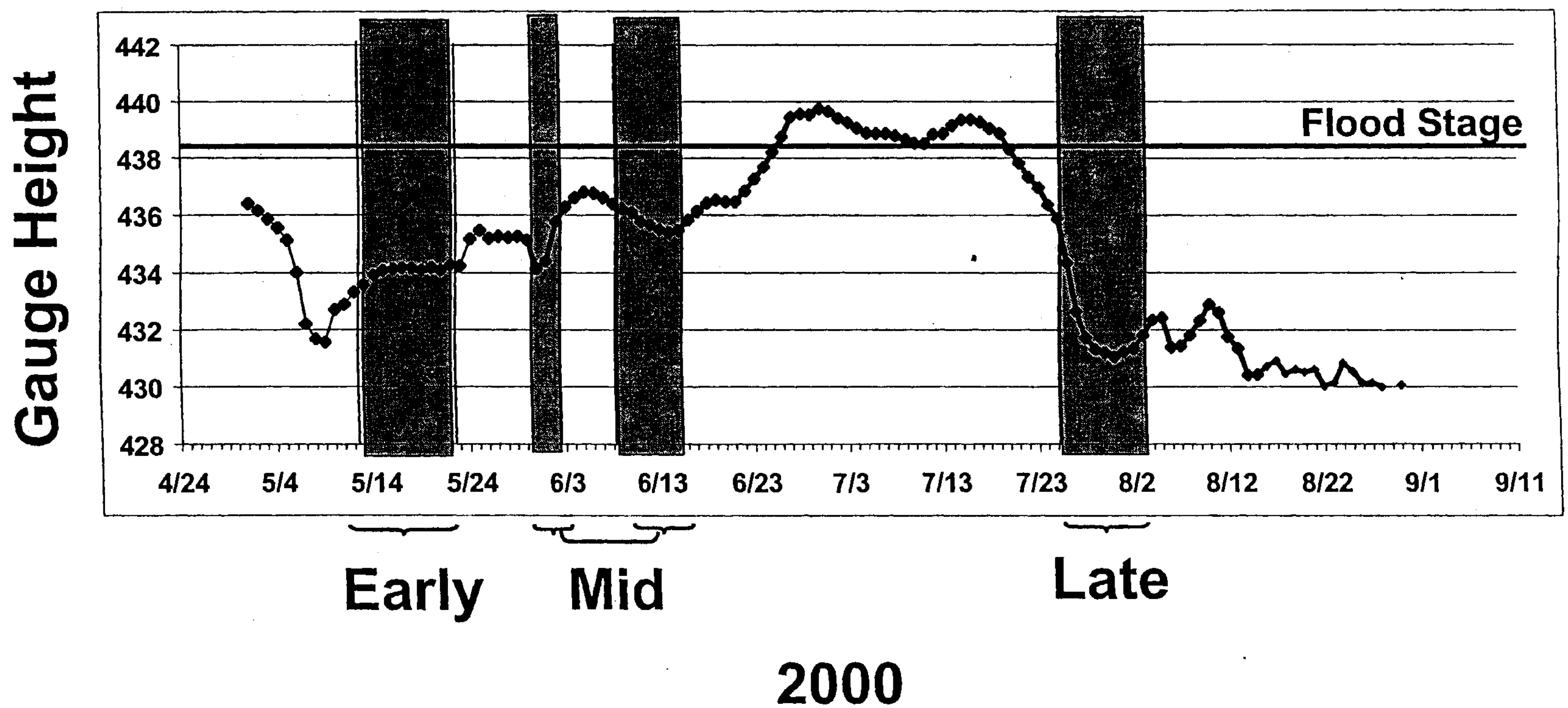


Figure 1. Hydrograph data for the Illinois River, obtained from the monitoring site near Havana, IL. Shaded areas represent escapement sampling periods at Lake Chautauqua.

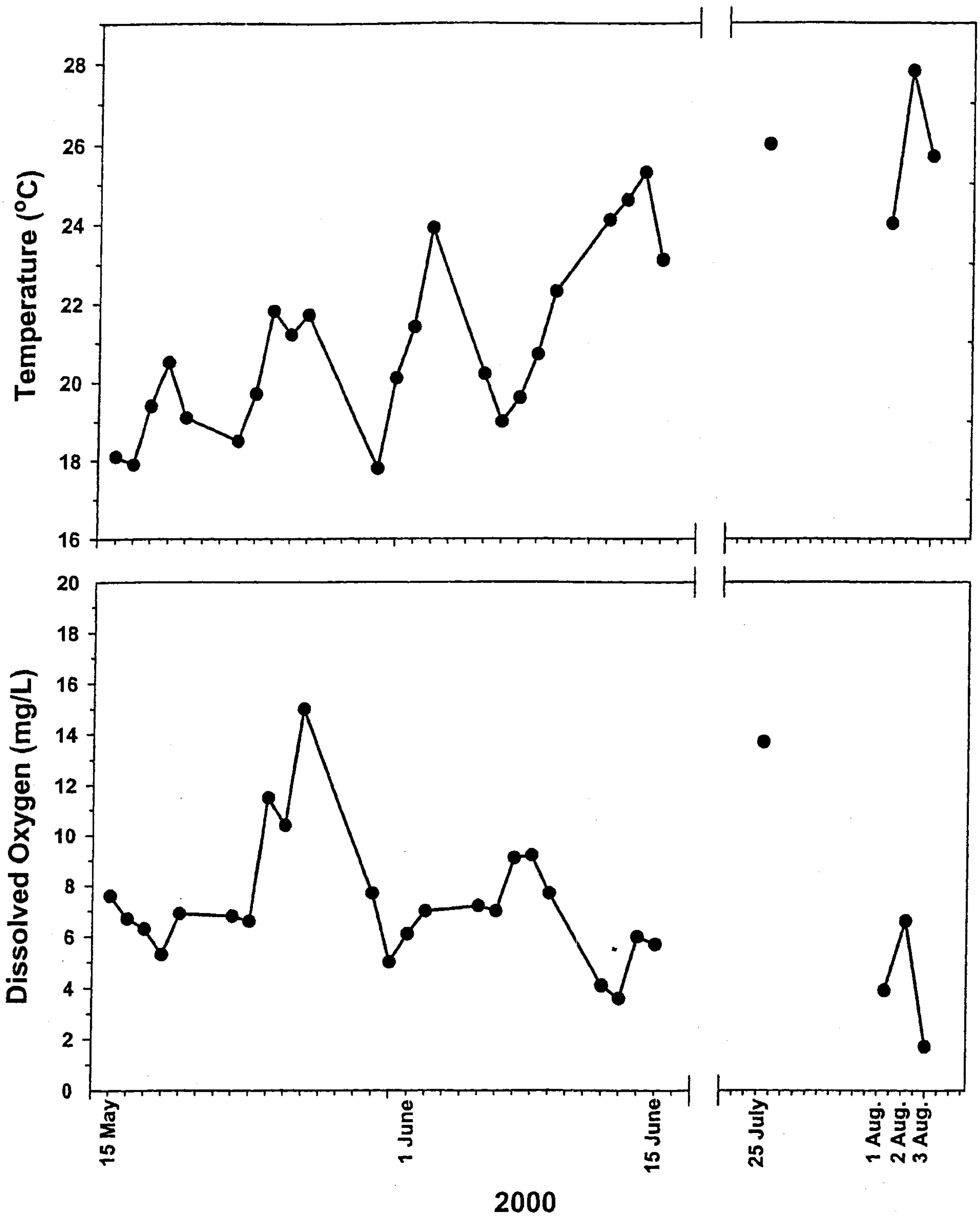


Figure 2. Temperature and dissolved oxygen during the entire 2000 escapement period (15 May-3 August) near the control structure at Lake Chautauqua.

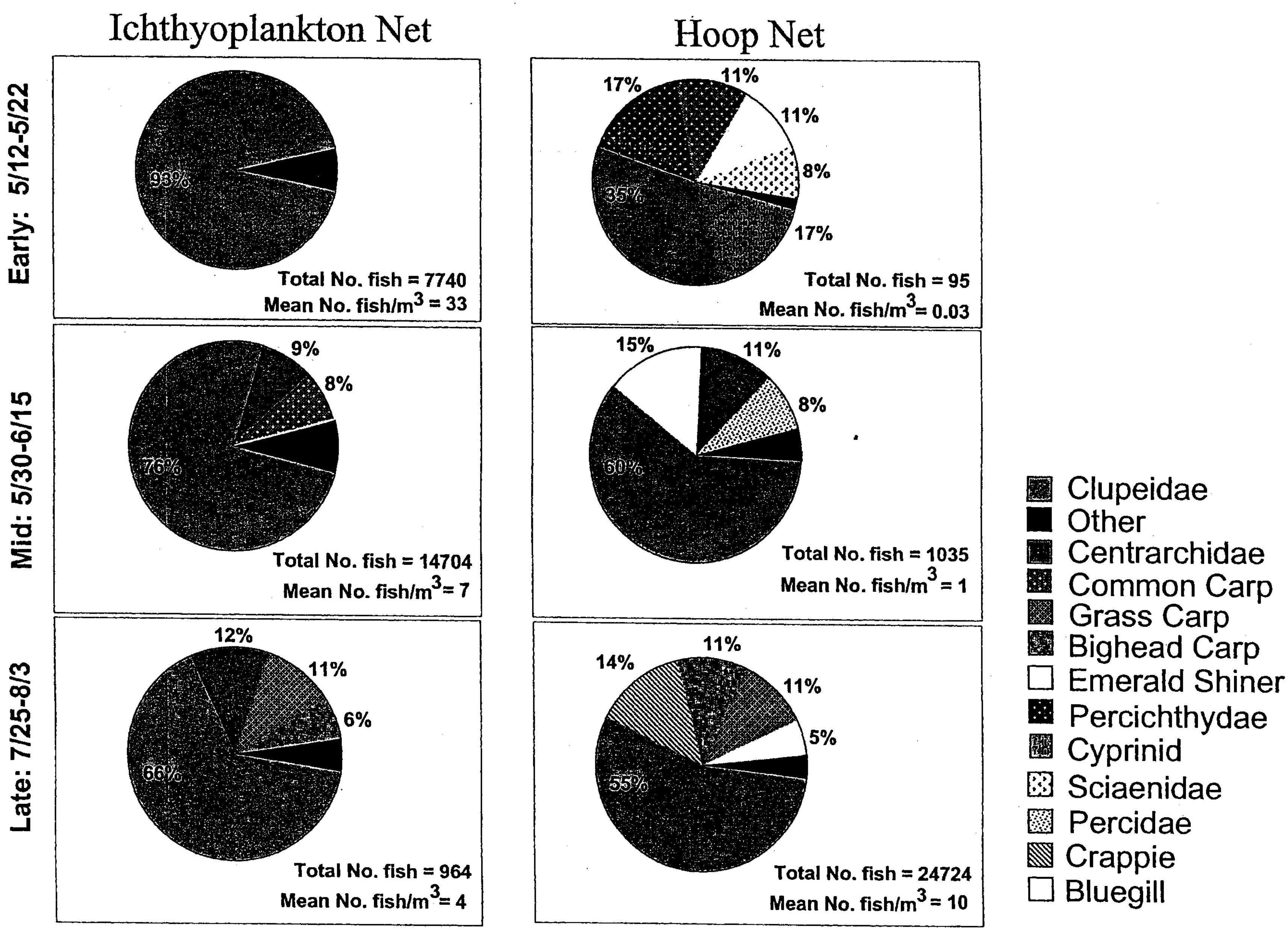


Figure 3. Fish composition in Lake Chautauqua effluent quantified in ichthyoplankton and hoop nets during early, mid, and late escapement periods.

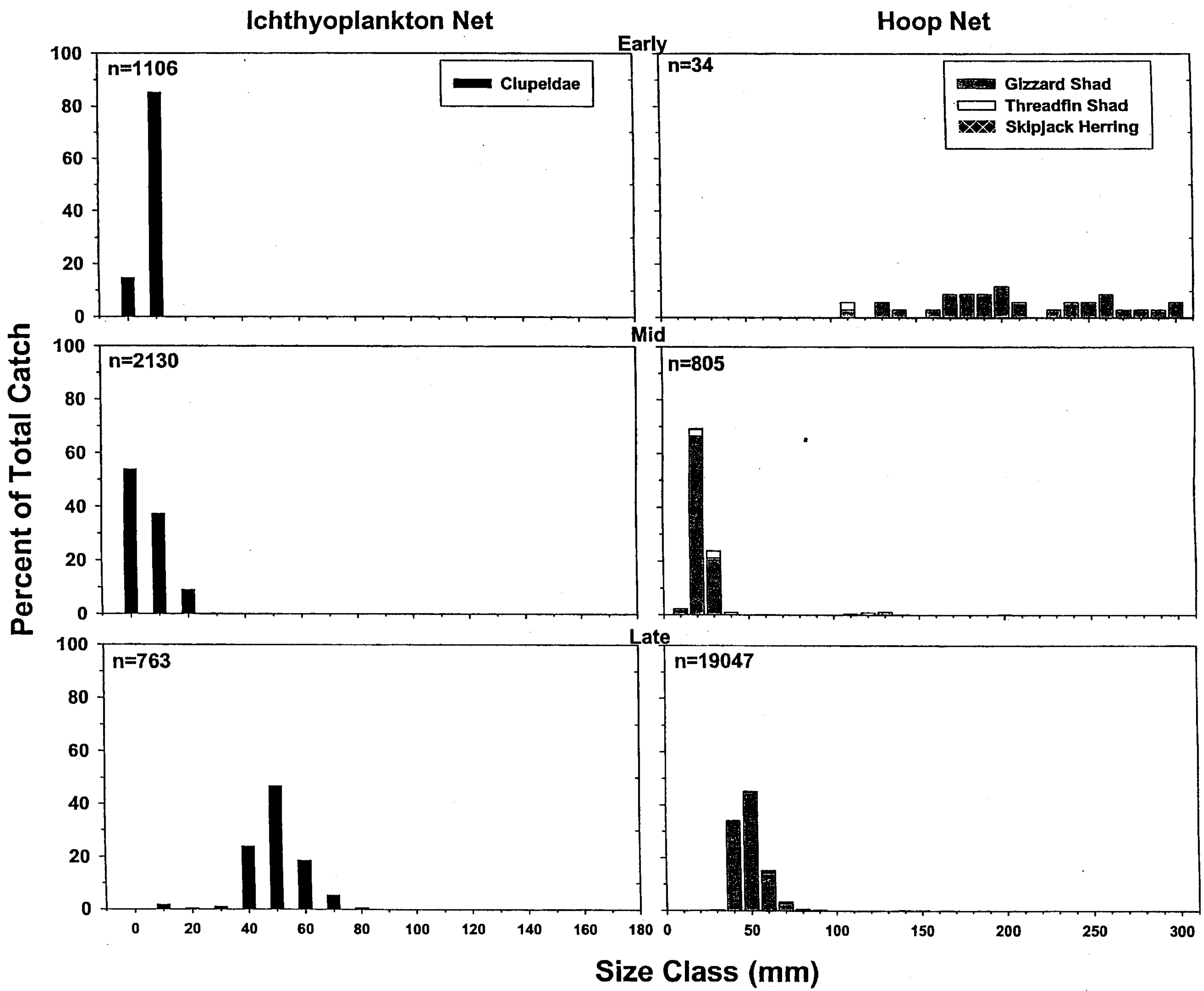


Figure 4. Size frequency distributions for clupeids collected in ichthyoplankton and hoops during early, mid,and late escapement from Lake Chautuaqua.

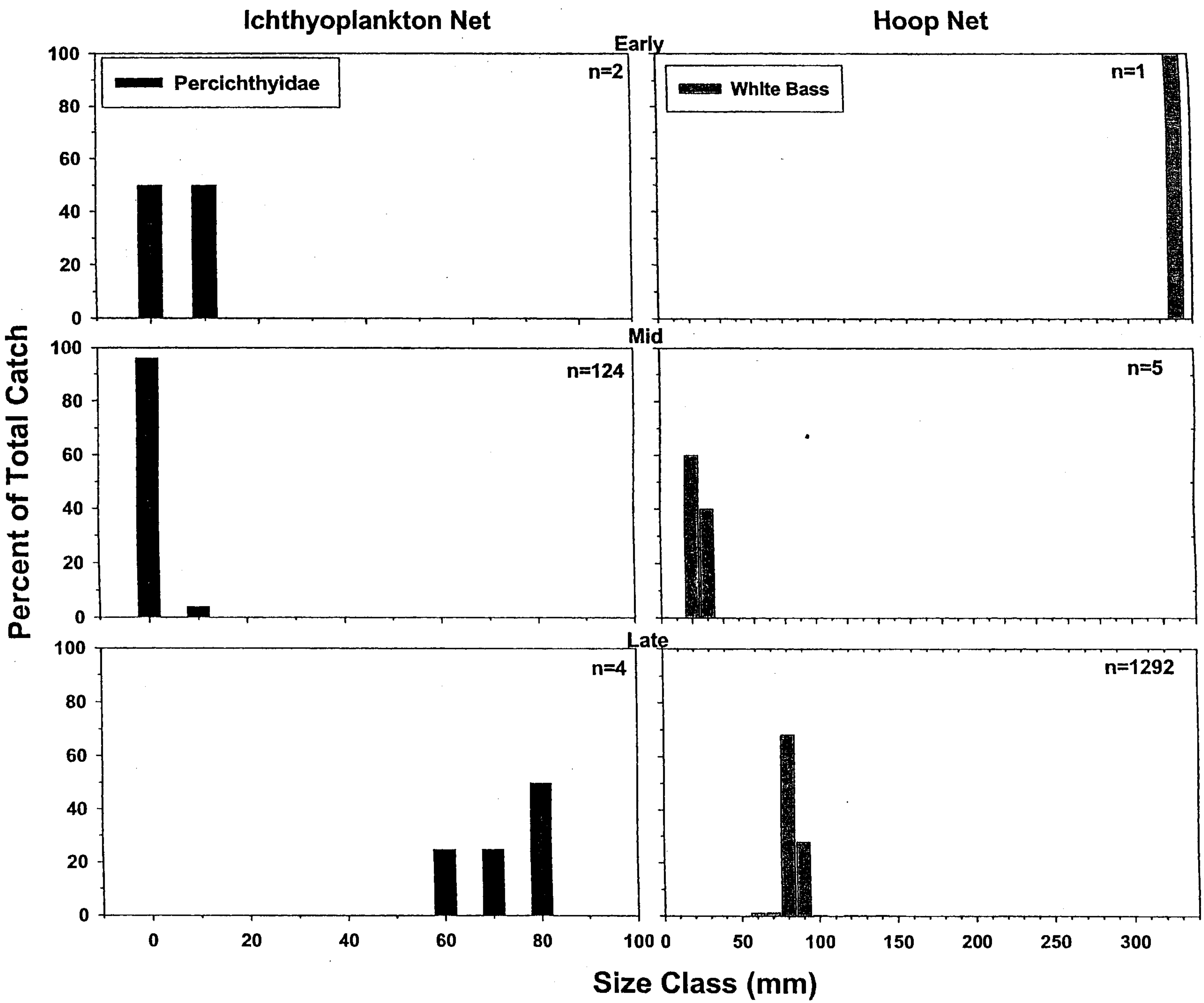


Figure 5. Size frequency distributions for percichthyids collected in ichthyoplankton and hoops during early, mid,and late escapement from Lake Chautuaqua.

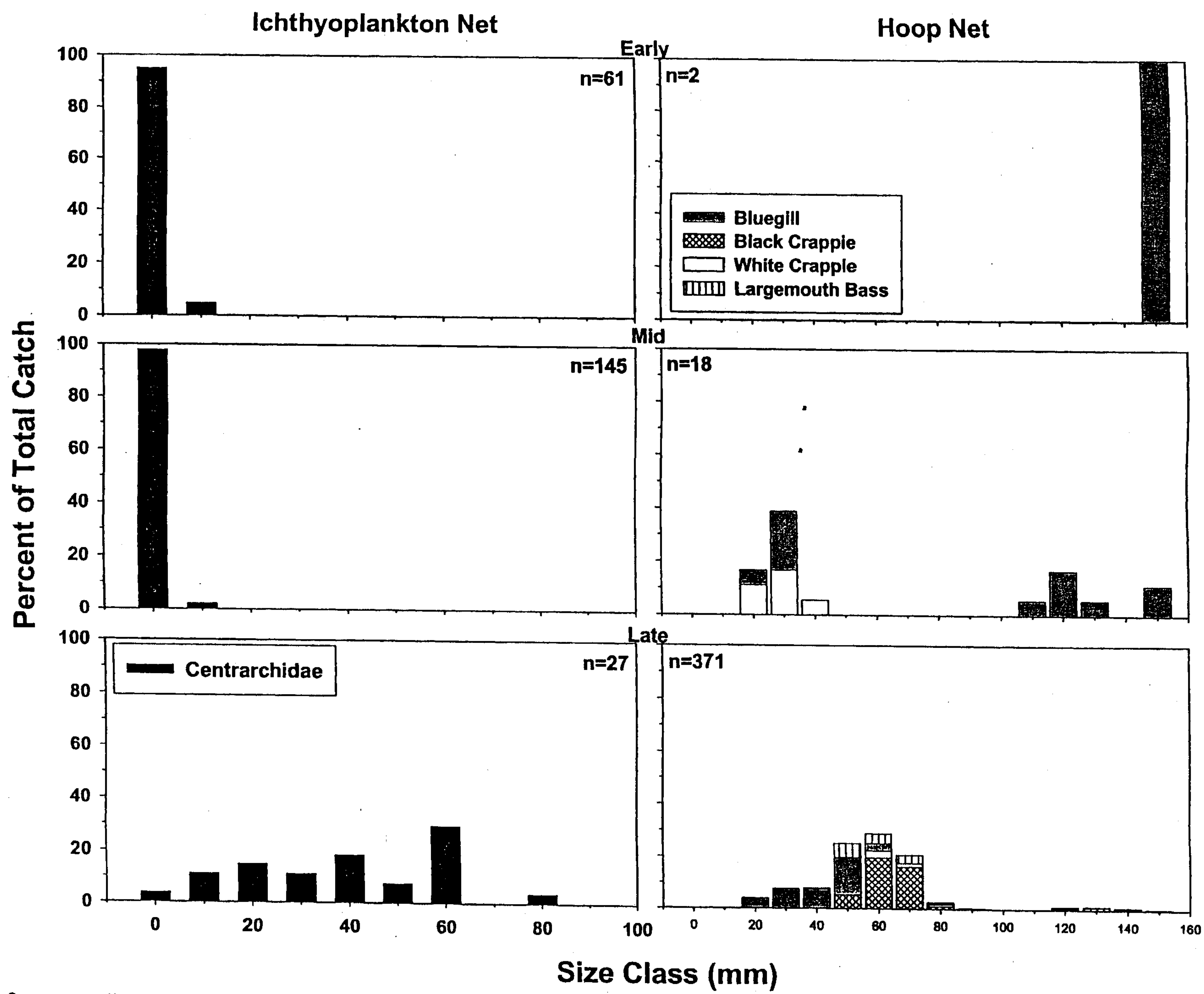


Figure 6. Size frequency distributions for centrarchids collected in ichthyoplankton and hoops during early, mid,and late escapement from Lake Chautuaqua.

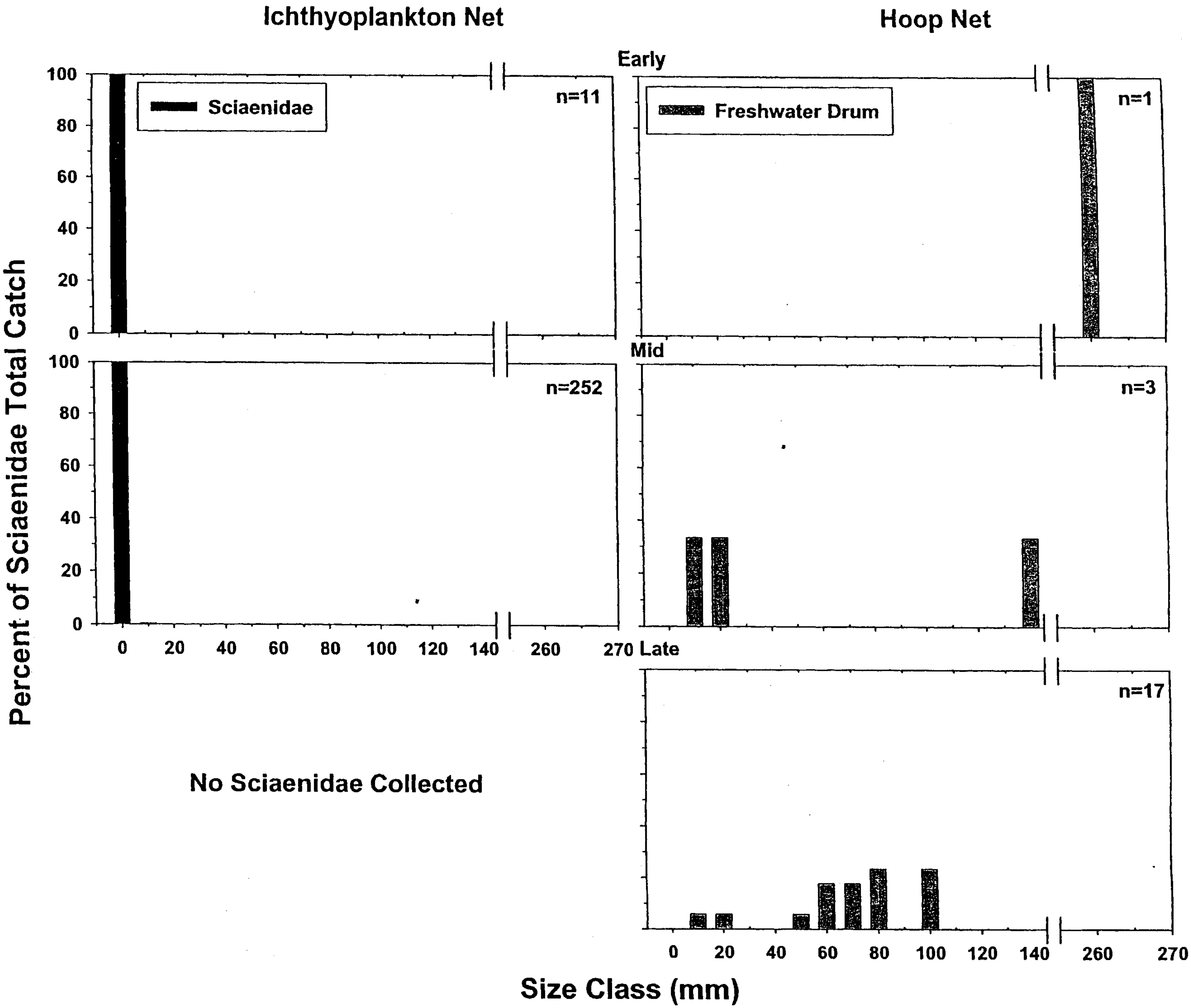


Figure 7. Size frequency distributions for sciaenids collected in ichthyoplankton and hoops during early, mid,and late escapement from Lake Chautuaqua.

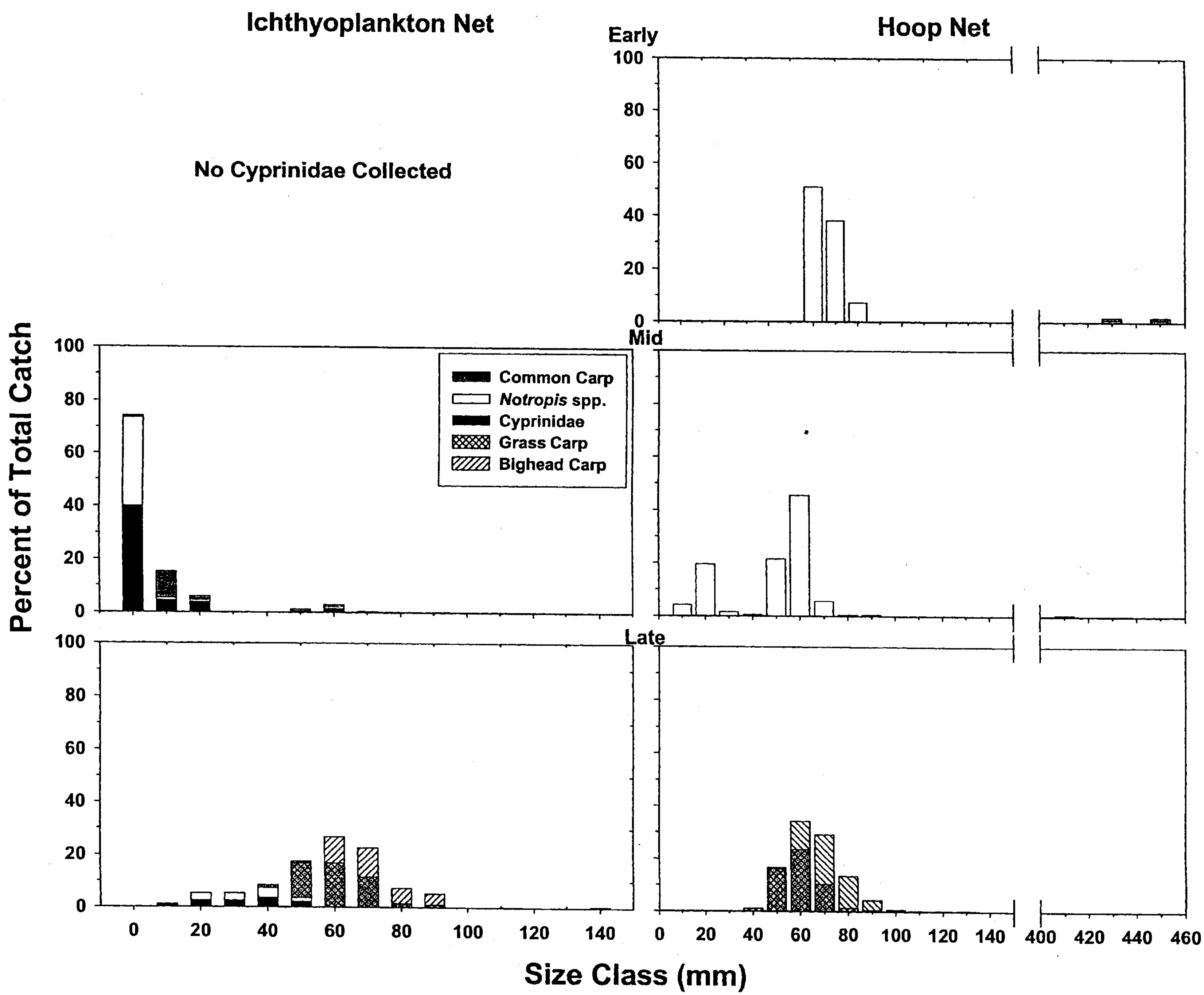


Figure 8. Size frequency distributions for cyprinids collected in ichthyoplankton and hoops during early, mid,and late escapement from Lake Chautuaqua.

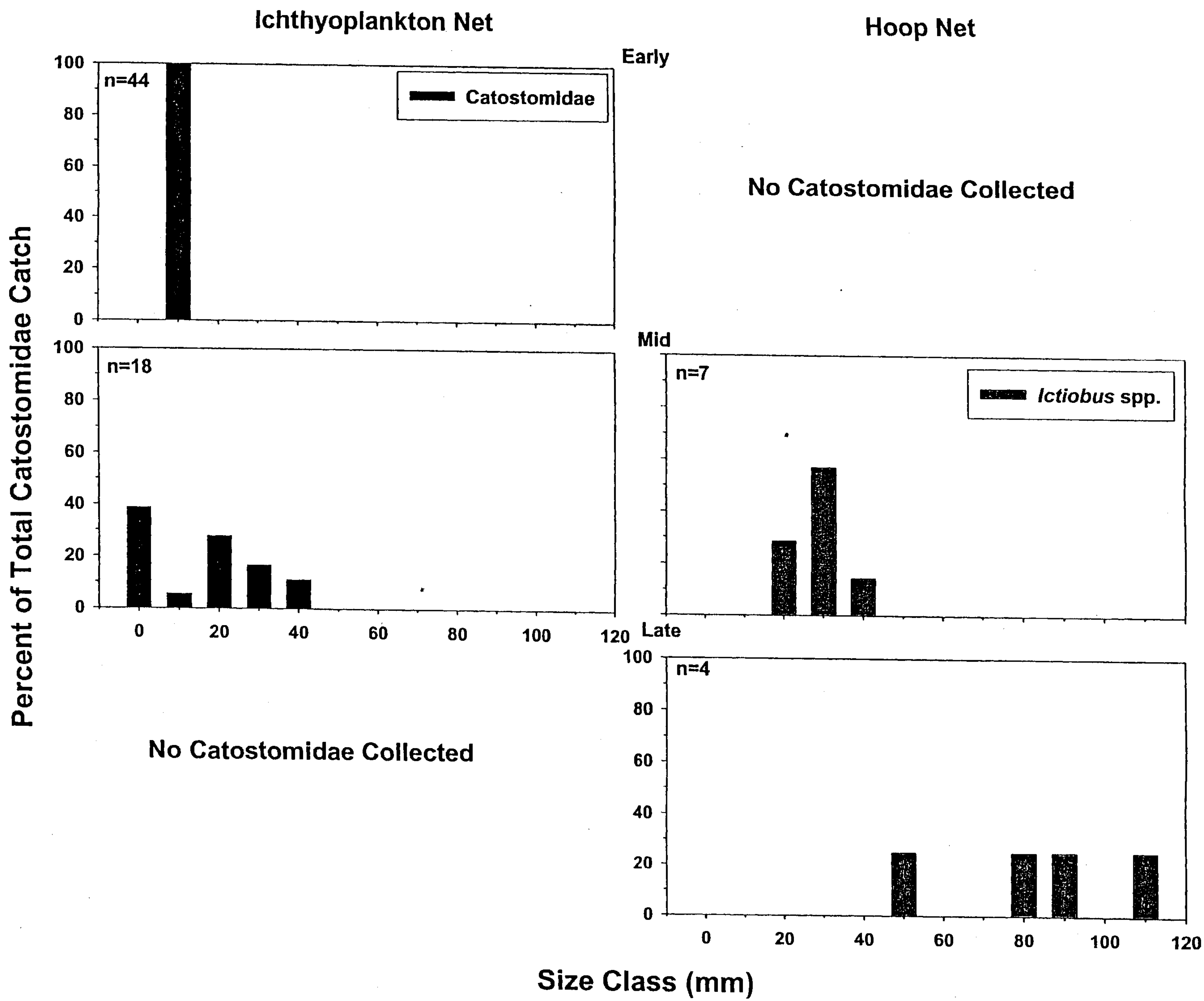


Figure 9. Size frequency distributions for catostomids collected in ichthyoplankton and hoops during early, mid,and late escapement from Lake Chautuaqua.

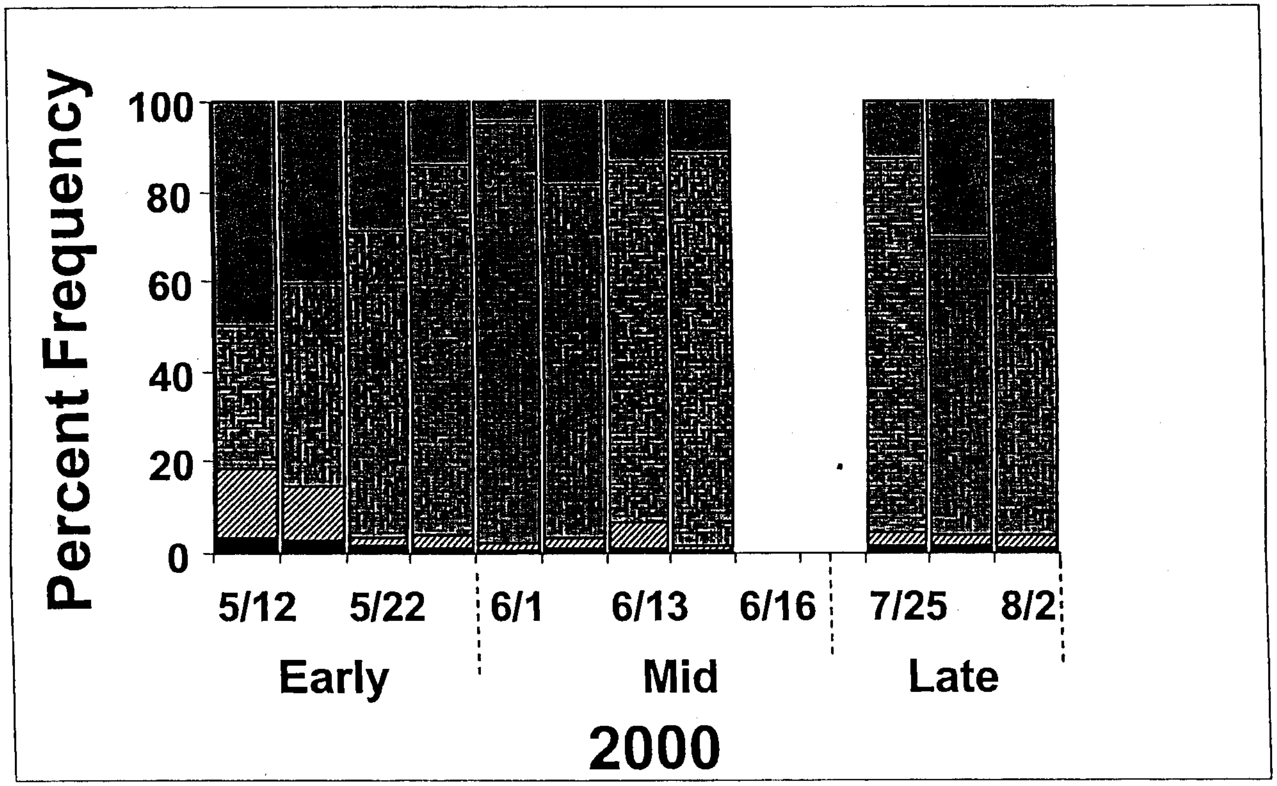


Figure 10. Zooplankton composition in Lake Chautauqua effluent during early, mid, and late escapement.
Legend: nauplii, rotifers, copepods, cladocerans.

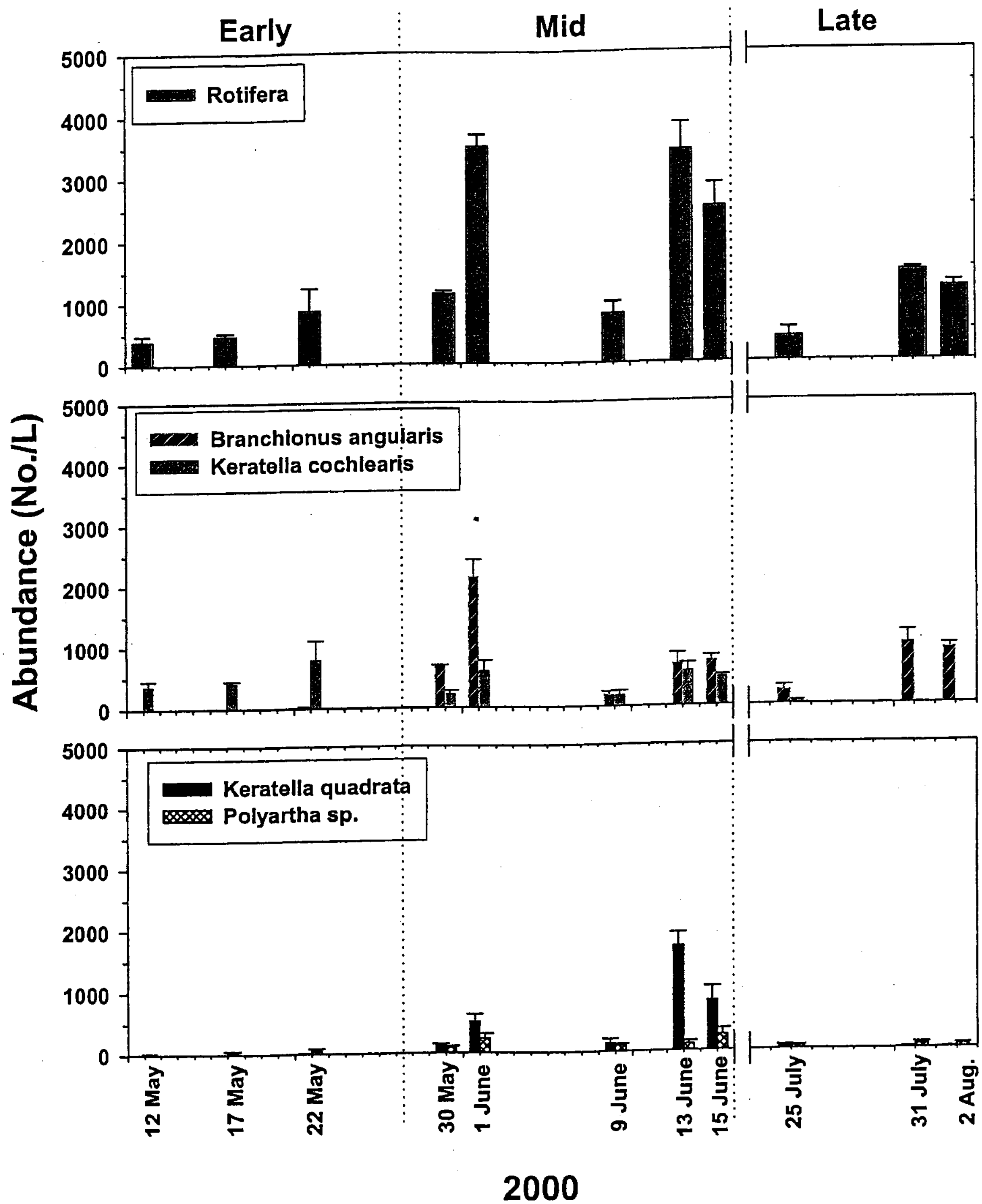


Figure 11. Abundances of total rotifers and dominant rotifer taxa collected during early, mid, and late escapement periods from Lake Chautauqua.

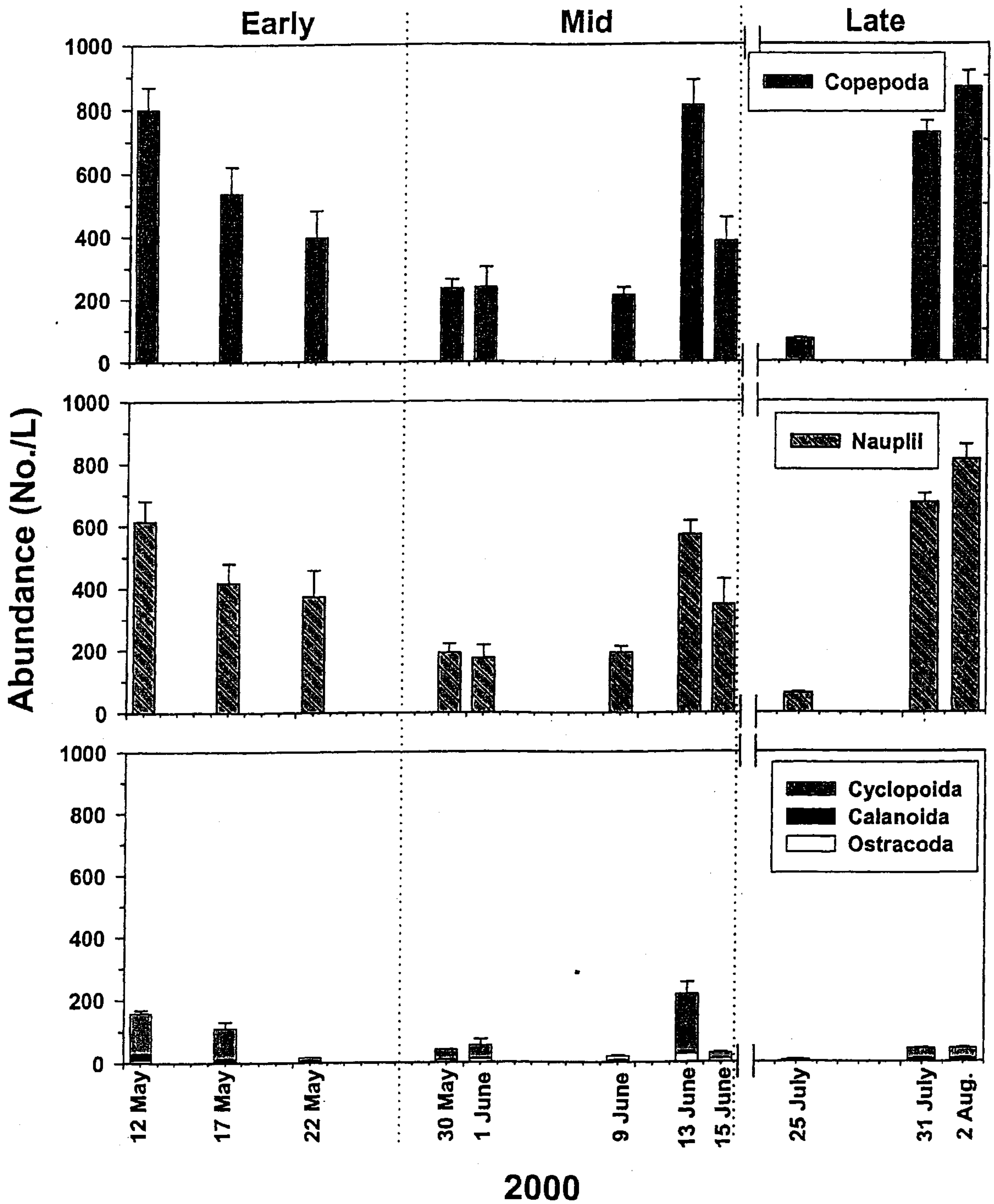


Figure 12. Abundances of total copepods and dominant copepod taxa collected during early, mid, and late escapement periods from Lake Chautauqua.

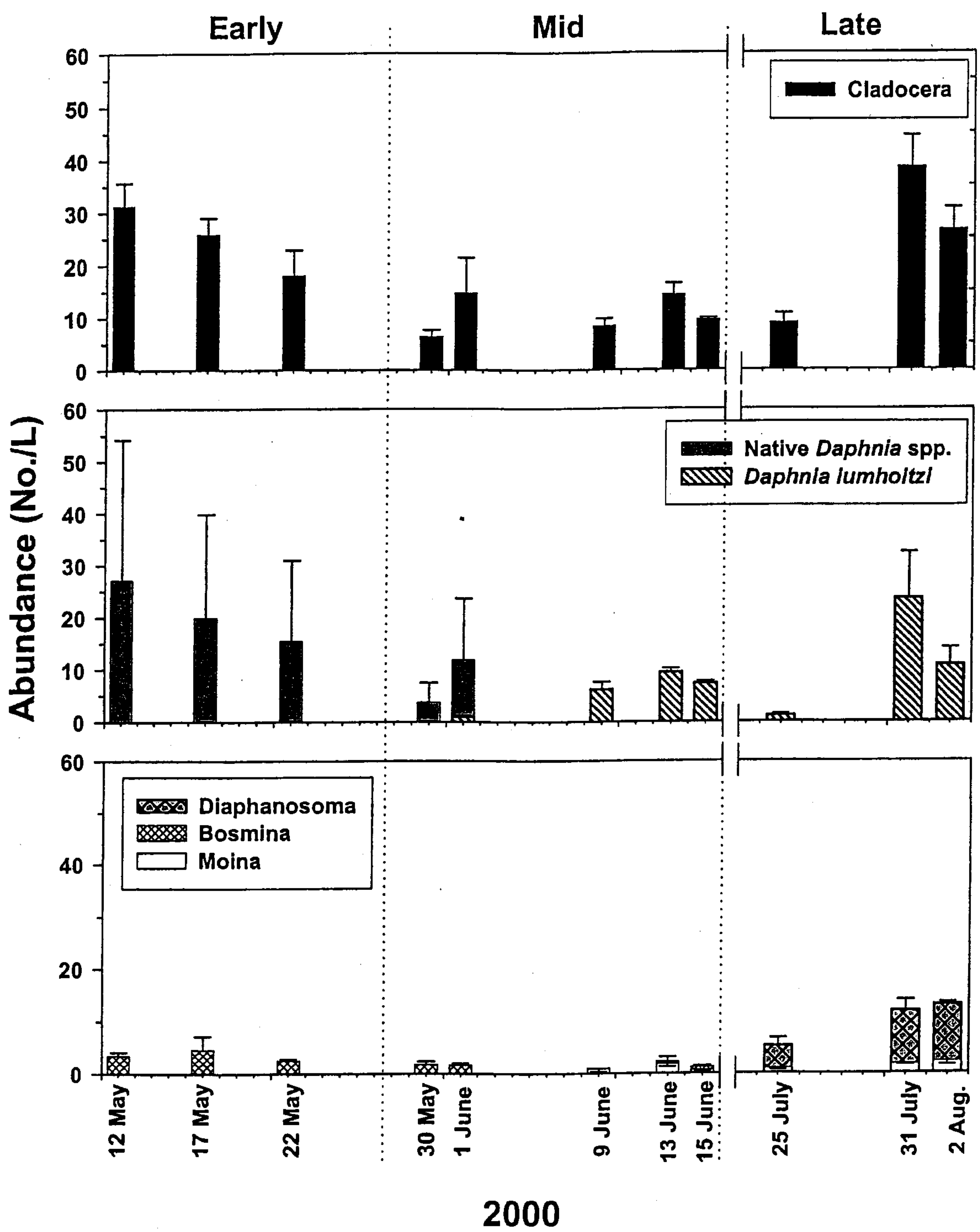


Figure 13. Abundances of total cladocerans and dominant cladoceran taxa collected during early, mid, and late escapement periods from Lake Chautauqua.

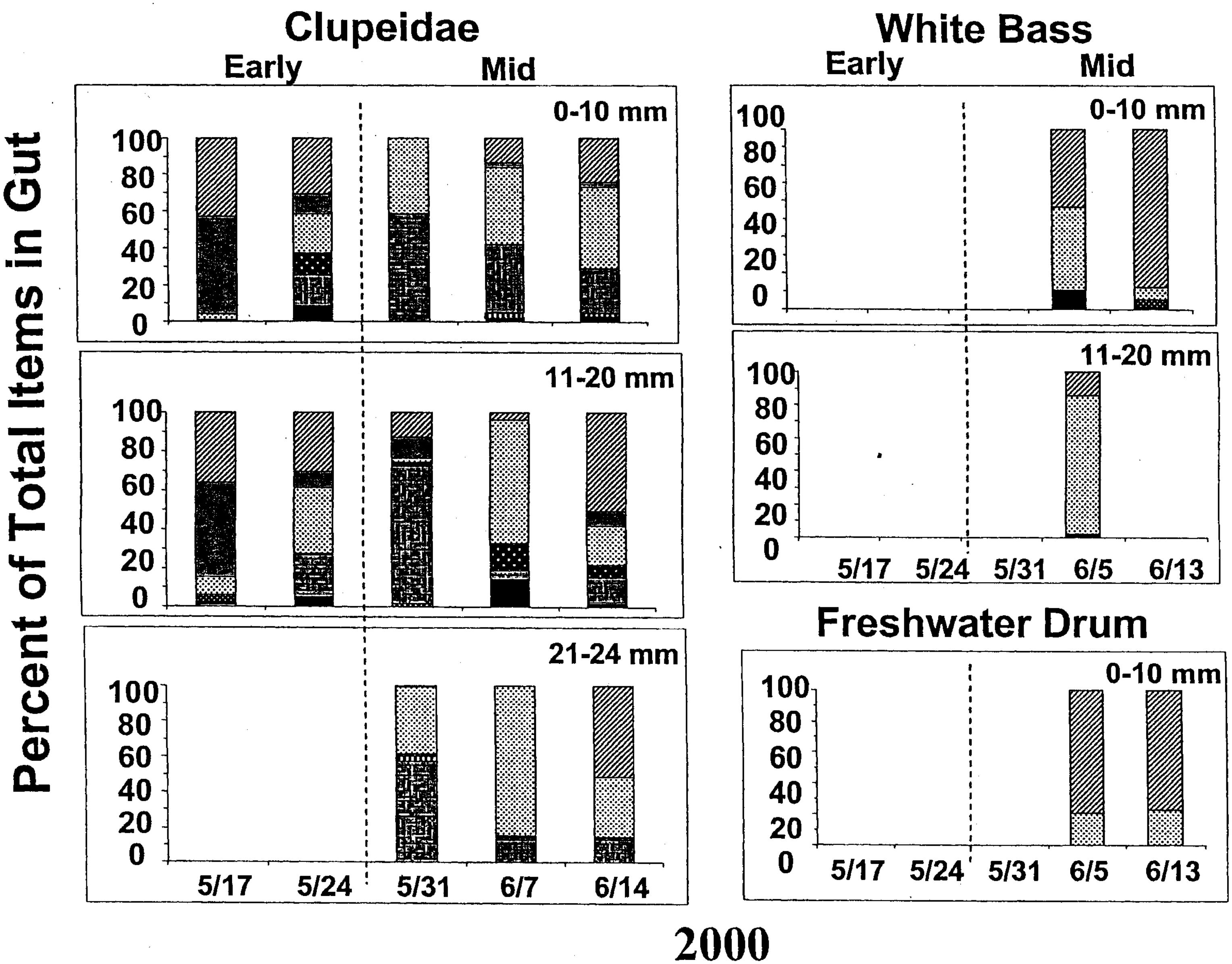


Figure 14. Diet composition of larval fish species. Legend: cyclopoid, nauplii, microcrustacean eggs, cladocerans, rotifers, unidentified, ostracoda.

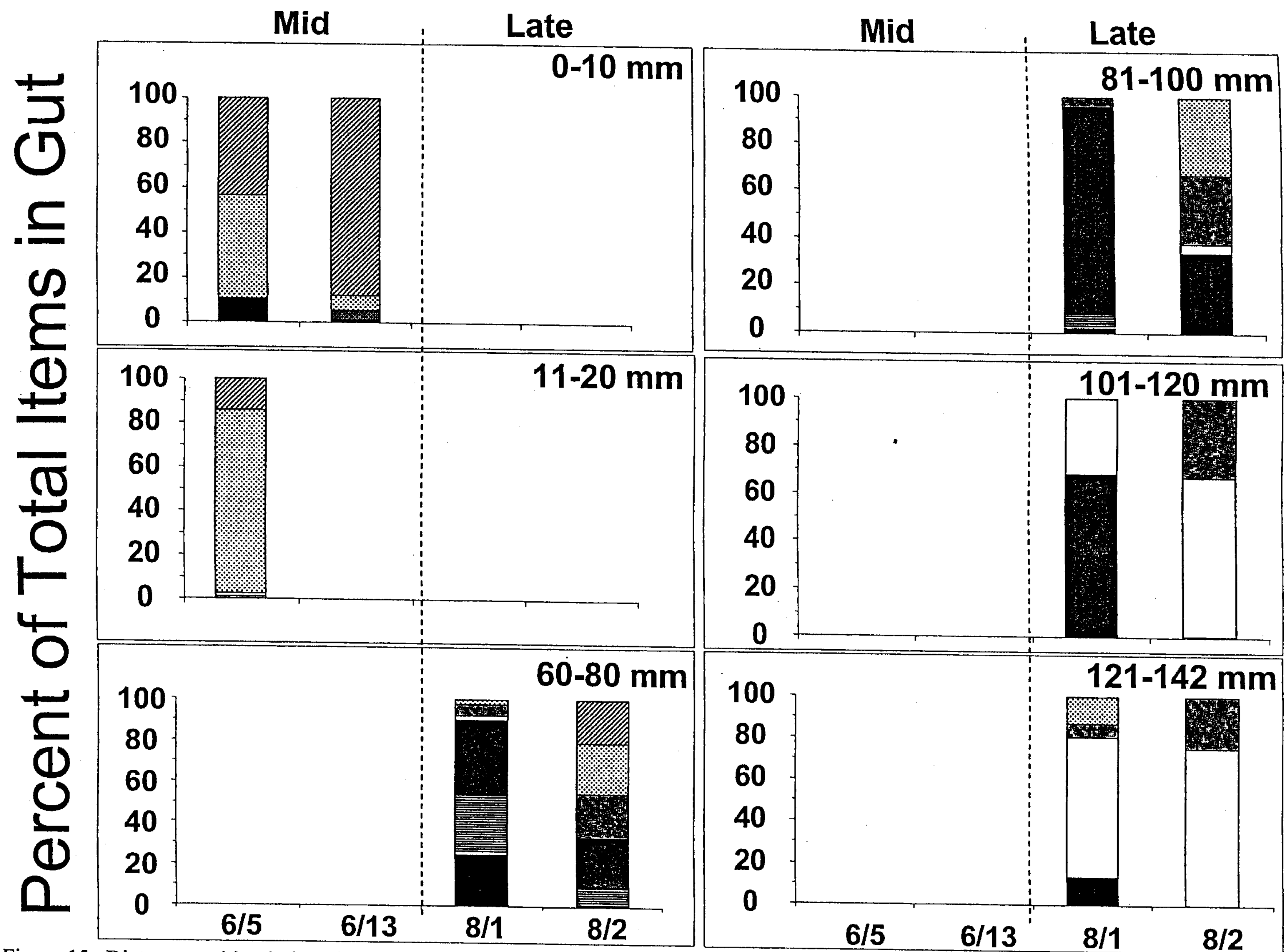


Figure 15. Diet composition in larval and juvenile white bass, *Morone chrysops*. Legend: cyclopoids, microcrustacean eggs, cladocerans, *Daphnia lumholtzi*, fish, corixids, chironomids, calanoids, unidentified.

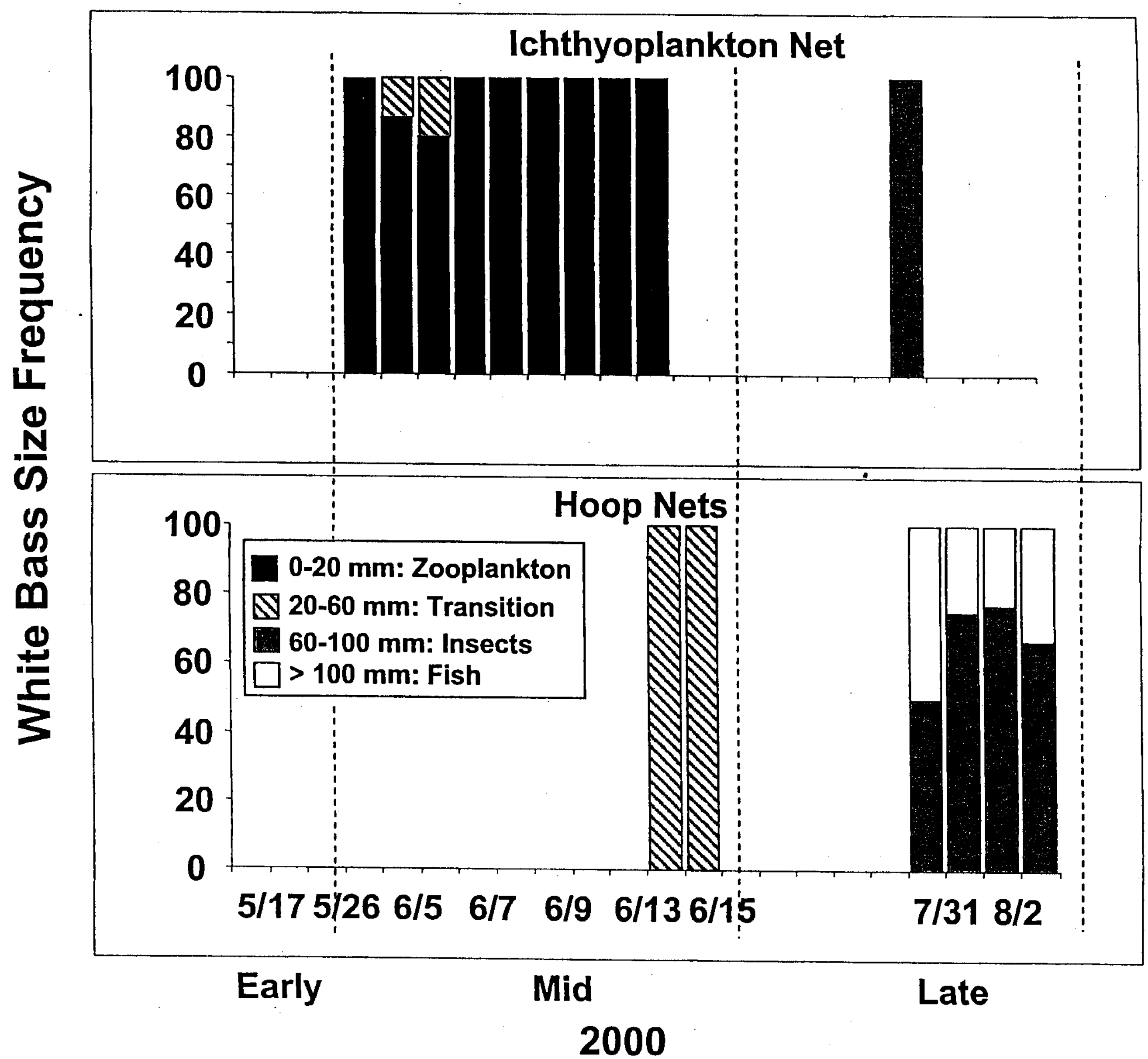


Figure 16. Diet shifts in larval and juvenile white bass, *Morone chrysops*, based on diet analysis.

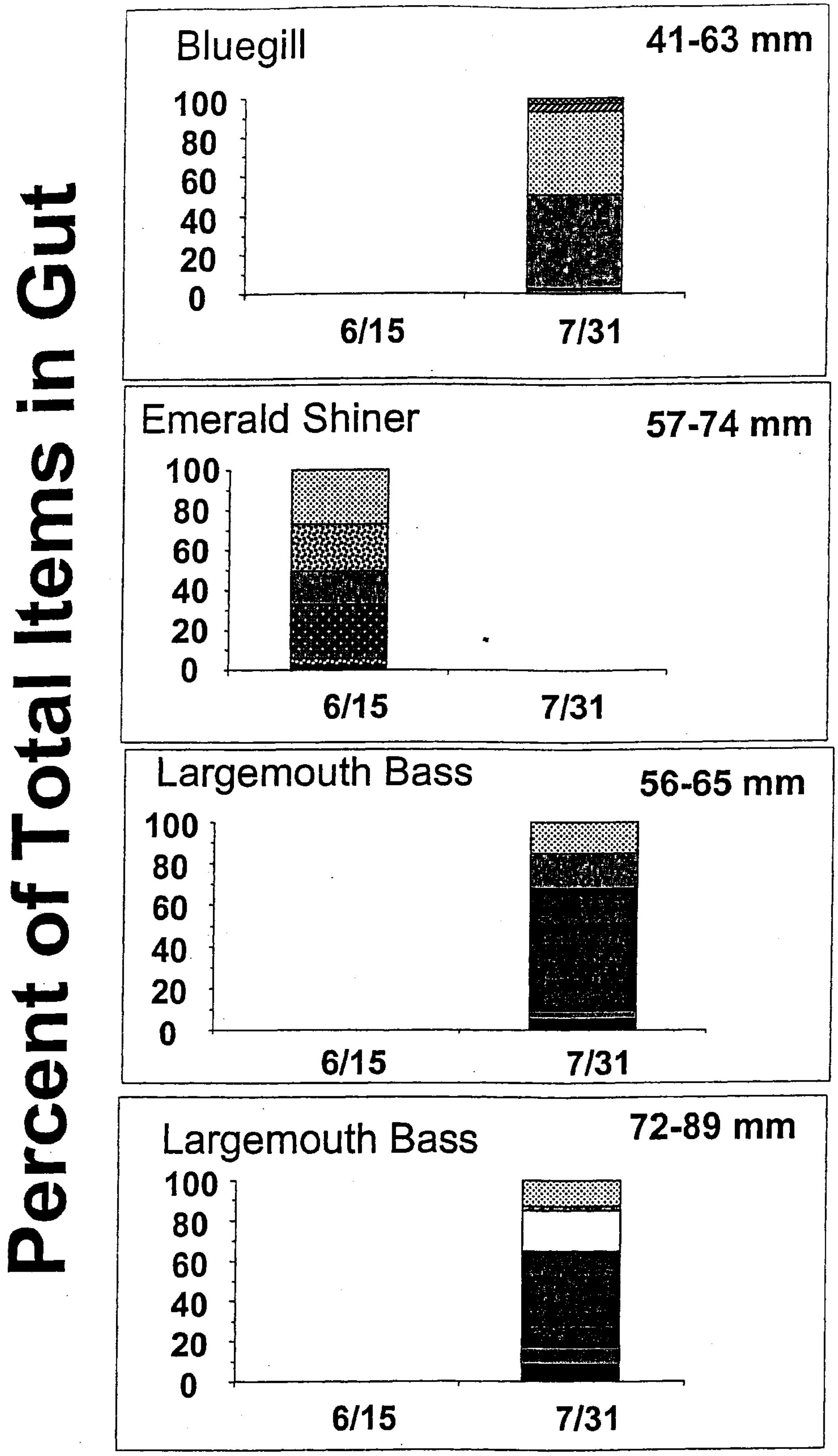


Figure 17. Diet composition of juvenile fish species and the utilization of *Daphnia lumholtzi* as prey. Legend: calanoids, cyclopoids, microcrustacean eggs, *Daphnia lumholtzi*, cladoceran ephippia, adult insects, mites, corixids, fish, unidentified, other.

Appendix A. Larval and juvenile fish collected during early, mid, and late escapement periods from the South cell of Lake Chautauqua during 2000. Units are: no. fish/m3 water exiting the South cell and estimated total no. fish exiting the South cell during each of the escapement periods. Fish included in the Appendix list are taxa that have been collected in the South cell of Lake Chautauqua sometime between 1996-2000.

			Ichthyoplankton Nets						Hoop Nets					
			Mean No./m3			Total Fish			Mean No./m3			Total Fish		
FAMILY	GENUS	SPECIES (common name)	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
Clupeidae														
	General		32.86	6.48	0.06	25651013.16	2236977.65	14750.57	0.00	>0.01	0.00	0.00	3583.37	0.00
	Dorosoma spp.		0.00	0.01	0.00	0.00	21262.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		cepedianum (gizzard shad)	0.00	0.07	2.66	0.00	122487.68	49652629.60	0.01	0.82	7.42	3304.29	393760.94	17658598.64
		petenense (threadfin shad)	0.00	0.01	0.05	0.00	8697.07	1597111.44	<0.01	0.04	0.10	2877.77	20675.50	181946.23
	Alosa													
		chrysochloris (skipjack herring)	0.00	0.01	<0.01	0.00	0.00	11156.45	0.00	<0.01	0.08	0.00	769.46	280992.89
	Total		**32.86**	**6.58**	**2.77**	**25651013.16**	**2389424.89**	**51275648.05**	**0.02**	**0.86**	**7.60**	**6182.06**	**418789.27**	**18121537.77**
Catostomidae														
	General		0.00	<0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Moxostoma	*macrolepidototm* (shorthead redhorse)												
		erythrurum (golden redhorse)												
	Carpiodes spp.	(carpsucker)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		velifer (highfin carpsucker)												
		carpio (rivercarpsucker)												
		cyprinus (quillback)												
	Ictiobus spp.	(buffalo)	0.22	<0.01	0.00	189025.41	2141.54	0.00	0.00	<0.01	<0.01	0.00	2094.30	4613.58
		bubalus (smallmouth buffalo)												
		cyprinellus (bigmouth buffalo)												
		niger (black buffalo)												
	Total		**0.22**	**<0.01**	**0.00**	**189025.41**	**2141.54**	**0.00**	**0.00**	**<0.01**	**<0.01**	**0.00**	**2094.30**	**4613.58**
Percichthyidae														
	General		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Morone	*chrysops* (white bass)	<0.01	0.06	0.02	2843.18	50286.18	517163.89	<0.01	<0.01	<0.01	202.76	2211.27	89334.26
		mississippiensis (yellow bass)												
		americana (white perch)												
		stripe X white bass hybrid												
	Total		**<0.01**	**0.06**	**0.02**	**2843.18**	**50286.18**	**517163.89**	**<0.01**	**<0.01**	**0.04**	**202.76**	**2211.27**	**89334.26**
Centrarchidae														
	General		0.01	0.00	0.00	1828.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Micropterus	*salmoides* (largemouth bass)	0.00	0.00	<0.01	0.00	0.00	118792.76	0.00	0.00	0.03	0.00	0.00	83643.58
	Pomoxis spp.	(crapple)	0.03	0.01	0.02	30402.67	19895.59	4793.36	0.00	0.01	0.11	0.00	3344.75	34252.24
		nigromaculatus (black crappie)												
		annularis (white crappie)												
	Lepomis spp.	(sunfish)	0.14	0.42	0.06	135406.12	282987.86	174705.35	0.00	0.00	0.00	0.00	0.00	0.00
		macrochirus (bluegill)							<0.01	<0.01	0.07	0.00	1858.68	103904.19
		cyanellus (green sunfish)												
		humilis (orange-spotted sunfish)												
		green sunfish X bluegill hybrid												
	Total		**0.18**	**0.43**	**0.08**	**167637.45**	**302883.45**	**298291.47**	**<0.01**	**0.01**	**0.21**	**0.00**	**5203.42**	**221800.01**
Sciaenidae														
	General		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Applodinotus	*grunniens* (freshwater drum)	0.03	0.16	0.00	24618.47	55918.24	0.00	<0.01	<0.01	0.01	119.97	730.74	9924.76
	Total		**0.03**	**0.16**	**0.00**	**24618.47**	**55918.24**	**0.00**	**<0.01**	**<0.01**	**0.01**	**119.97**	**730.74**	**9924.76**
Atherinidae														
	General		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Labidesthes	*sicculus* (brook silverside)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Hiodontidae														
	General		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hiodon	*alosoides* (goldeye)												
	Total		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Appendix A. continued.

			Ichthyoplankton Nets						Hoop Nets					
			Mean No./m3			Total Fish			Mean No./m3			Total Fish		
			Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
FAMILY	**GENUS**	**SPECIES (common name)**												
Ictaluridae														
	General		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ictalurus spp.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.01	0.00	0.00	294.09
		punctatus (channel catfish)												
	Ameiurus spp.													
		nebulosus (brown bullhead)												
		natalis (yellow bullhead)												
		catus (black bullhead)												
	Total		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**<0.01**	**0.00**	**0.00**	**294.09**
Amiidae														
	Amia	*calva* (bowfin)												
Esocidae														
	Esox	*lucius* (northern pike)												
Lepisosteidae														
	General		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lepisosteus	*platostomus* (shortnosed gar)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		osseus (longnosed gar)												
		occulatus (spotted gar)												
	Total		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Cyprinidae														
	General		0.00	0.02	0.00	0.00	8222.60	0.00	0.00	0.03	0.00	0.00	15101.82	0.00
	Notemigonus	*crysoleucas* (golden shiner)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.01	96967.04	0.00	6523.47
	Notropis spp.													
		atherinoides (emerald shiner)	0.00	0.05	0.06	0.00	85661.63	80678.00	0.01	0.12	<0.01	5861.78	62133.42	5603.16
		shumardi (silverband shiner)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.01	0.00	0.00	144.33	0.00
		blennius (river shiner)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cyprinella	*lutrensis* (red shiner)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lythrurus	*umbratilis* (redfin shiner)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Campostoma	*anamalum* (stoneroller)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pimephales	*vigilax* (bullhead minnow)	0.00	0.00	<0.01	0.00	0.00	9817.22	0.00	0.00	<0.01	0.00	0.00	1383.46
		notatus (bluntnose minnow)	0.00	0.00	0.00	0.00	0.00	0.00	<0.01	0.00	0.00	120.37	0.00	0.00
	Fundulus	*notatus* (blackstripe topminnow)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.01	0.00	0.00	169.96	0.00
	Carassius	*carpio* (common carp)	<0.01	0.19	0.00	2071.11	56560.80	0.00	<0.01	<0.01	<0.01	3168.54	162.49	1568.27
		auratus (goldfish)												
		carp X goldfish hybrid												
	Ctenopharygodon	*idella* (grasscarp)	0.00	0.00	0.30	0.00	0.00	4982430.65	0.00	0.00	1.18	0.00	0.00	4347558.54
	Hypopthalmichthys	*nobilis* (bighead carp)	0.00	0.00	0.19	0.00	0.00	1596218.39	0.00	0.00	0.96	96967.04	0.00	3625760.40
	Total		**<0.01**	**0.25**	**0.55**	**2071.11**	**142078.28**	**6669144.26**	**0.01**	**0.15**	**2.16**	**9150.69**	**77712.02**	**7988401.46**
Percidae														
	General		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Perca	*flavescens* (yellow perch)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Stizostedion	*canadense* (sauger)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.01	0.00	0.00	138.82
		vitreum (walleye)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Percina	*caprodes* (logperch)	0.00	<0.01	0.00	0.00	357.17	0.00	<0.01	<0.01	0.00	1092.87	2368.60	0.00
	various	darters	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total		**0.00**	**<0.01**	**0.00**	**0.00**	**357.17**	**0.00**	**<0.01**	**<0.01**	**<0.01**	**109.29**	**236.86**	**138.82**
Unidentified	Unidentified		0.04	0.02	0.00	13738.56	19899.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL			**33.34**	**7.51**	**3.42**	**26050947.34**	**2971356.25**	**58760247.68**	**0.03**	**1.02**	**10.01**	**15866.15**	**506977.89**	**26436044.74**